WINTER 74
HIVER 74

The foothills of the Rockies are a cradle for the beef industry

Les vallons des Rocheuses constituent un endroit privilégie pour la production du boeuf.

CANADA AGRICULTURE

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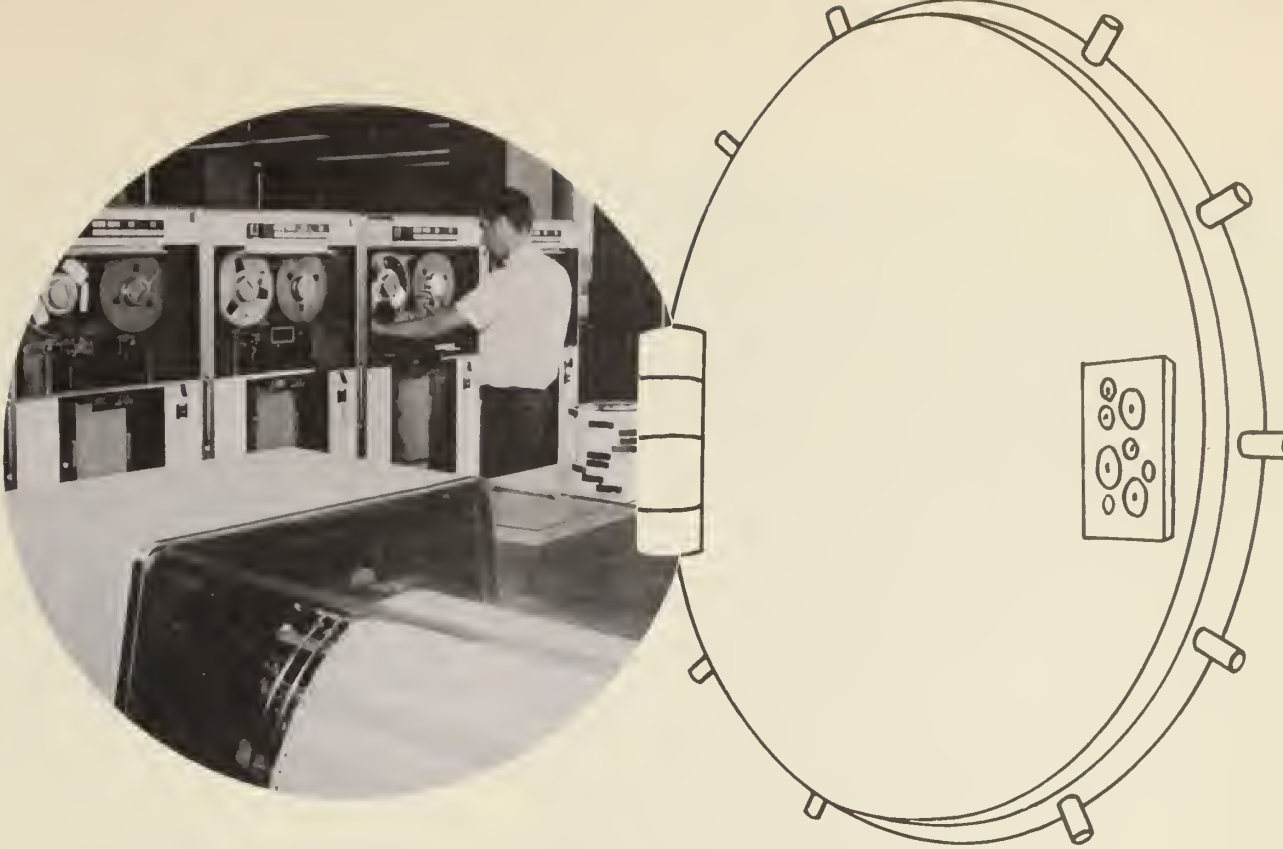

AGROMETEOROLOGICAL DATA BANK

W. BAIER and D.A. RUSSELO

A cause de la demande croissante de données et de services climatologiques et agrométéorologiques à la Section d'agrométéorologie, l'Institut de recherches chimiques et biologiques a décidé d'élaborer un programme et des méthodes d'acquisition de données à des fins de recherche et cela à des coûts raisonnables.

There is increasing use of climatological and agrometeorological data in the analysis and interpretation of field experiments and other research. Requests for more data, and the type of processing and programming provided by the Agrometeorology Section of CDA Chemistry and Biology Research Institute are coming from other CDA establishments and outside agencies. These requests, along with more diversified research have increased the responsibilities and work load of the Section. It has reached the point where it has become necessary to establish a policy and procedures for acquiring data in order to control the cost. This has been done in collaboration with the Climatic Data Processing Division of the Atmospheric Environment Service (AES) and the Data Processing Division, (DPD) of Agriculture Canada.

The following outline of the Agrometeorological Data Bank will be of interest to potential users of the information and others concerned with the effect of weather and climate on farm production.

DATA ACQUISITION

The Atmospheric Environment Service is the national agency responsible for the collection and provision of meteorological data. There are 289 principal and 2,223 climatological stations in Canada. Precipitation is observed at 1,950 stations, extreme temperatures at 2,439, soil temperature at 61, sunshine at 295, and evaporation at 129. Included in the number of climatological stations are 41 agrometeorological stations jointly administered by AES and CDA.

Arrangements have been made with the Data Processing Division of Agriculture Canada to receive all data from the AES. To minimize purchases, and to avoid duplication in data preparation for agricultural research, CDA Agrometeorology Section obtains

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meteorological data from the AES, verifies and stores it in an Agrometeorological Data Bank, while D.P.D. administers the service orders. In developing these data files, close liaison has been maintained with the Canadian Soil Information Systems (CanSIS) developed by the Soil Research Institute, in order to ensure computer compatibilities of the agrometeorological and soil data files. A CANFARM-CanSIS-AGROMETEOROLOGY pilot project to prepare a data collection package is in the planning stage.

DATA FILES

At present, the Agrometeorological Data Bank consists of the three main types of climatological data files detailed below, together with several smaller files of related data (see Table 1).

1. *Daily data,* in No. 4 format, contain maximum and minimum air temperatures, rainfall, snowfall, total precipitation and snow on the ground for some 85 stations over a period of at least 40 years. It is expected that daily records of sunshine and soil temperatures will also be included in these files at a later date.
2. *Monthly summary data* for 1,200 stations recorded over periods, in most cases, over 30 years. The data include mean monthly maximum, minimum and mean temperatures, deviation of mean temperatures from normals, maximum rainfall and date, highest snowfall and date, maximum precipitation and date, totals of rainfall, snowfall and precipitation, departure of total precipitation from the mean and also extreme monthly temperatures. Also included are the number of days with certain temperature and precipitation events (frost, snow, hail, thunderstorms, etc.), wind frequencies and degree-day accumulations.
3. *Normal data cards* for the same 1,200 stations for the 1941-70 period, as published by the AES, are also available. These normals include most of the elements listed above under the monthly summary cards.

SPECIAL AGROMETEOROLOGICAL DATA

The Agrometeorology Section also maintains special agrometeorological data files. For example, soil moisture reserves are determined in spring and fall at some 40 sampling sites across Canada. The data are collected through the cooperation of CDA and University personnel presently at nine CDA Research Branch establishments (Beaverlodge, Edmonton, Lacombe, Lethbridge, Indian Head, Melfort, Regina, Swift Current and Lennoxville) and University Departments. A knowledge of the soil moisture reserves is useful for seasonal crop yield predictions and operational decisions on fertilizer and irrigation requirements by crops. Additional studies are needed to determine the practical value of soil moisture data for these and other practical applications. However, it has been demonstrated already that such data are invaluable for the development and verification of climatological soil moisture budgeting models and their various uses in agricultural planning.

The Agrometeorological Data Bank also includes records of soil temperature, evaporation, crop yields and other biological data.

EXAMPLES FOR APPLICATIONS

Irrigation requirement probabilities computed from daily data at 59 stations in Canada have been published in a series of Technical Bulletins for use of farmers. Methods developed to relate results from daily computations over 30 growing seasons to monthly climatological normals has made it possible to obtain estimates for 700 locations. Coloured maps of seasonal water deficits in Canada are now being prepared from these derived data.

Soil temperature and soil water regimes, evaluated from daily agrometeorological data, have been classi-

TABLE 1 SUMMARY OF CLIMATOLOGICAL DATA AVAILABLE IN DATA BANK

Record Type	Contents	Approximate Total of Station Years
4	Maximum and minimum temperature, rain, snow, total precipitation, snow depth	3,400
10	Hourly sunshine and daily total	200
11	Hourly radiation and snow depth	120
12	Soil temperatures at standard depths	240
17	Precipitation, A.M. and P.M. wet/dry bulb and dewpoint temperatures, sunshine, wind, evaporation	140
S41-2	Monthly averages of temperature and precipitation data	14,400
Normal	30-year means of temperature and precipitation data	1,200

TABLE 2 NET RETURNS AND ECONOMIC VALUE OF ONE INCH OF WATER (SPRING SOIL MOISTURE STORAGE + GROWING SEASON PRECIPITATION) FROM FALLOW-SEEDED AND CONTINUOUS WHEAT PER CULTIVATED ACRE. (FROM BAIER, AGRIC. METEOROL. 9: 305-321)

Practice	Wheat Price per bu.	Net Return		Value of One Inch of Water
		50% Probability	10% Probability	
Fallow wheat	$1.35	$ 7.07	$15.55	$2.07
	1.50	8.30	17.73	2.30
	1.65	9.53	19.89	2.53
	1.80	10.76	22.07	2.76
	1.95	11.98	24.24	2.99
Continuous wheat	1.35	9.87	26.28	4.13
	1.50	11.55	29.78	4.59
	1.65	13.23	33.29	5.05
	1.80	14.91	36.79	5.51
	1.95	16.59	40.29	5.97

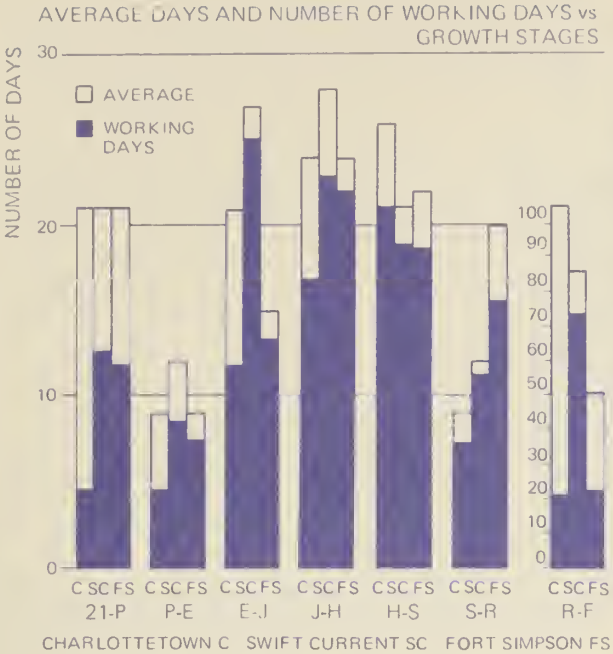
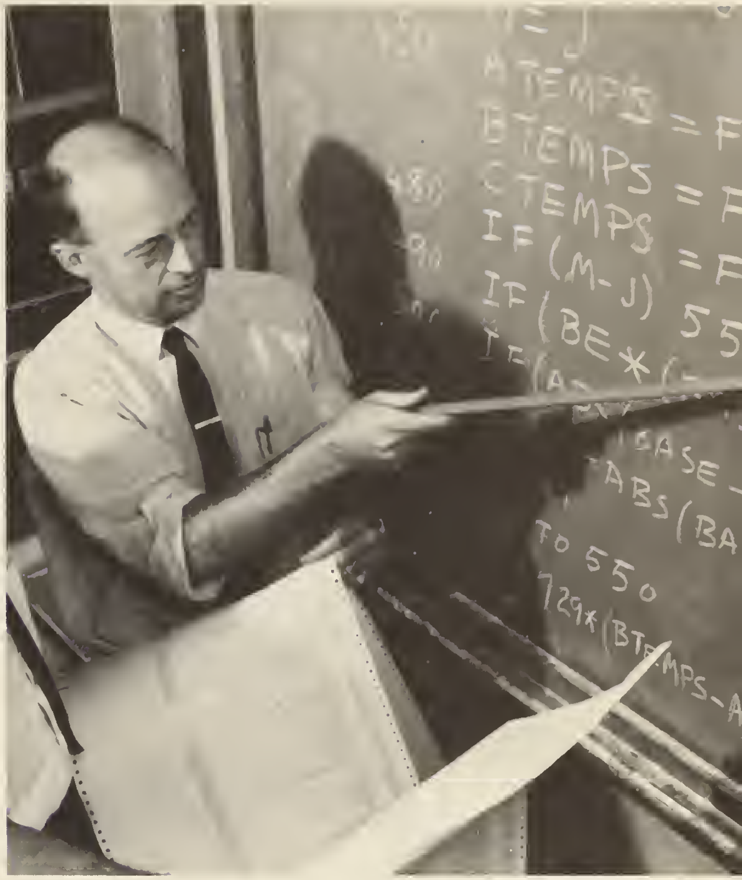


Figure 1 Average (50% probability) number of workdays based on estimated soil moisture data for selected periods of field work and wheat crop development stages at three CDA stations (1931-60).

P=Planting; E=Emergence; J=Jointing; H=Heading; S=Soft dough; R=Ripe; F=Freeze-up.



fied. These have been compiled by the Soil Research Institute into the Soil Climate Map of Canada. Monthly data have been used, particularly in seasonal weather-based crop yield estimations and in developing a climatological soil temperature model.

Long-term soil moisture data derived from climatological water-budgeting models have been employed successfully as a basis for crop-weather analyses, probabilities of field workdays (Fig. 1) and evaluations of the economic benefits of fallow-seeded and continuous spring wheat in southern Saskatchewan (Table 2).

The publications dealing with data applications are too numerous to be listed here; they are given in the annual CDA Research Branch Reports and in a special newsletter-type bulletin entitled "Selected Canadian Agrometeorological Publications" (SCAP), available from the Agrometeorology Section, CDA Chemistry and Biology Research Institute, Ottawa.

HOW CAN AGROMETEOROLOGICAL DATA BE OBTAINED?

Requests for agrometeorological data should be directed to the Agrometeorology Section, CBRI, preferably with some explanation about the proposed use of the data. If possible, the user will be given professional advice by an agrometeorologist who is familiar with the problem, the area and the type of data requested. Researchers are encouraged to seek this advice since it has been found that in most cases data users benefit from the experience of others who have worked with the data. The cost of data verification, preparation and processing has been reduced because unnecessary duplication of data purchases and processing has been avoided. Arrangements can be made with the Agrometeorological Section, either for obtaining copies from existing data files or for purchasing the data by agreement with the Climatic Data Processing Division of AES in accordance with their meteorological fees regulations.

It should be recognized that the Agrometeorological Data Bank has some limitations compared with approximately 88 million records on file with the AES. Nevertheless, the advantage of the CDA bank lies mainly in the fact that the data, at least for the agricultural research stations, have been verified, organized and processed in such a way that they are more readily available for agricultural research purposes without further manipulation. These agrometeorological data files are also compatible with the soil data files and possibly other information collected by CDA establishments. ■

A REPRIEVE FOR CEREALS IN QUEBEC

Kamouraska clay soil after plowing and disking in fall 1972.

J. E. COMEAU, G. M. BARNETT
and R. RIOUX

La céréaliculture est-elle rentable au Québec? Non, si la préparation du sol doit être faite au printemps, disent ces spécialistes de la Ferme expérimentale fédérale de La Pocatière. La clé, selon eux, réside dans la préparation du sol et le drainage en surface faits à l'automne, permettant de semer tôt au printemps.

Many agronomists and farmers in Quebec have come to the conclusion that cereal grains are not profitable under present cultural methods. They are taking a look at corn and alfalfa as alternatives for feed production.

Before giving up on barley and oats however, they should consider how these cereals have been produced in the past.

CEREALS IN MONOCULTURE

In Quebec, cereals have been grown largely as a nurse crop for forage establishment. Those who compare oats and corn are not making valid comparisons because corn is grown in monoculture. Yield of cereals is bound to be low if grown with a forage. Not only that but cereals have been seeded at a lower rate so that the forage plants are not smothered! If grain is required then cereals must be grown in monoculture, just as the West has done for the past 100 years.

CEREAL ADAPTABILITY

Except for the Ste Hyacinthe—Ormstown corridor, corn and alfalfa are marginal crops in Quebec. One only has to recall that alfalfa is severely damaged one winter in three. A crop that matures in Southern U.S. at the end of August and barely ripens—if at all—in Quebec by October, must be regarded as marginal.

Cereals on the other hand are better adapted to Quebec. They start to germinate at 38°F. They need soils with high moisture content, cool temperatures and long days to produce high yields. They require early seeding. In the lower St. Lawrence, oat yields drop about 1 bushel per acre for every day seeding is delayed from the end of April to 12th May and by 3 bushels per acre for every day seeding is delayed from 12th to June 1st.

Long days, cool temperatures, and moist soil trigger the physiology of the high yields. In cereals these conditions occur about the first of May or in April. Meteorological records show that rains are more frequent in late May than early May. The farmer who misses seeding in early May may have to wait a week or two for the weather to clear and that will cost him money.

Early seeded cereals mature earlier, and can be harvested before the fall rains and periods of low evapotranspiration occur. This allows time for fall plowing and disking. The problem with corn is that it is harvested so late that fall plowing and disking are

Mr. Comeau is superintendent, Mr. Barnett and Mr. Rioux are agronomists at CDA Experimental Farm, La Pocatière.

not always possible. If plowing is delayed till spring, the opportunity to seed early is lost.

Increased bushel weight and decreased lodging are other advantages of early seeding cereals.

OBJECTIONS TO EARLY SEEDING

Farmers often say that their cereals may freeze if seeded too early. However, pasture grasses that are also full of water are not affected by late frosts. In trials at Kapuskasing, late frosts in May have not affected cereals, including a late frost on May 22 when the cereals were 4 inches high. Farmers say that the soil can still be frozen under the surface even though the surface is dry. This is often so, but remember that large vegetables can be grown in the Yukon on perma-frost! By the time the cereal roots penetrate the soil, the sub-soil has thawed. If the soil is 40°F when seeded, the sub-soil will soon thaw.

Farmers say they can't seed early because there are snow banks. Snow banks can always be cleared with a snow blower and a road opened to the field. Generally, fields are ready to seed long before the last snowbank has disappeared.

SOIL PREPARATION

Farmers say they can't disk early in the spring because they don't have the traction. That is right! Farmers had no traction problem with the horse. Four footed animals could lift their feet out of wet spots when drawing a light disk. But wide heavy disks of today, set at 5 or 6 inches, need power and the tractors required to pull them can't lift their back feet. Early seeding therefore is more difficult with tractor power. The technology of the horse does not apply to the tractor.

What then, is the new technology for early seeding?

FALL PREPARATION

The answer is very simple. Disk and harrow in the fall after plowing. If the soil is prepared in the fall, seeding can be carried out in the spring as soon as there is a dry crust on the soil. The soil will support a tractor and seeder but not a tractor and disk.

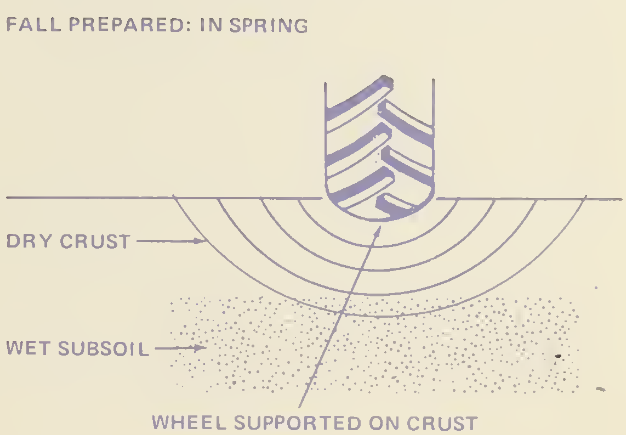
THE MERITS OF FALL PREPARATION

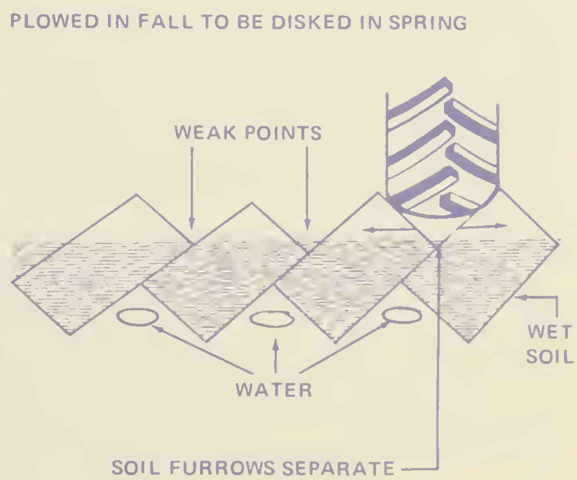
Experiments at La Pocatière have shown that harrowing with a spring tooth harrow before seeding is advantageous because weed competition is reduced. Harrowing loosens the top 2 inches of soil, creating dry mulch in which weeds do not grow well. However, fall prepared soil allows the seed to be placed at the interface of the moist subsoil and dry layer created by harrowing. This gives the cereal an advantage over the weeds.

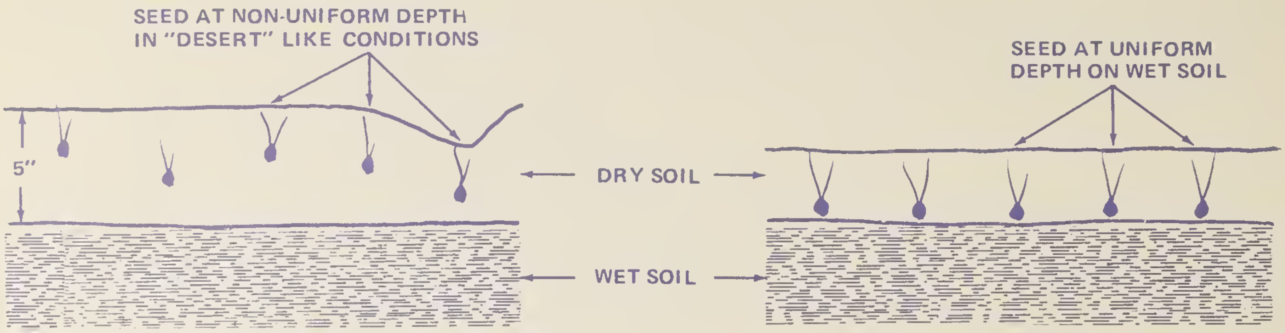
The problem with spring prepared soils is that the surface 4 or 5 inches is a virtual desert as far as the seed is concerned. The soil has to be packed well with a press wheel, or compacted by rain before seeds absorb enough moisture for uniform germination. But there is always a lot of water in the soil in the spring so why not use it? Prepared in the fall, soil will have reestablished its structure during the winter and

The same Kamouraska clay soil in spring 1973. The winter had reduced the clods to a fine firm seedbed.

Fall prepared soils allow seeding to be accomplished earlier.







Seeding depth in spring-prepared soils is non-uniform.

Seeding depth in fall-prepared soils is uniform.

spring and the seed can be placed on the moist subsoil—not at different levels in a dry seed-bed. Seeding depth is easily controlled. Is it not illogical to destroy the soil structure established by freezing and thawing during the winter by spring disking?

Soils plowed late in the fall are generally wet, and when disked clod easily, particularly if there is much clay in them. However, these clods are broken down by spring into a fine seed bed. It has been said that fall preparation causes the soil—particularly clays—to be too hard for the seed disks to penetrate. This may be true if seeding is delayed until late May, but is not the case on clays at La Pocatière if seeded early. Fall prepared soils are normally in better condition for early seeding, and in fact should be seeded early. If seeding is retarded to mid or late May the soil becomes compact and hard. This is particularly true on soils with a high clay content. In this latter case any benefits gained by fall preparation are lost—the soil will have to be re-worked with the disc and harrow.

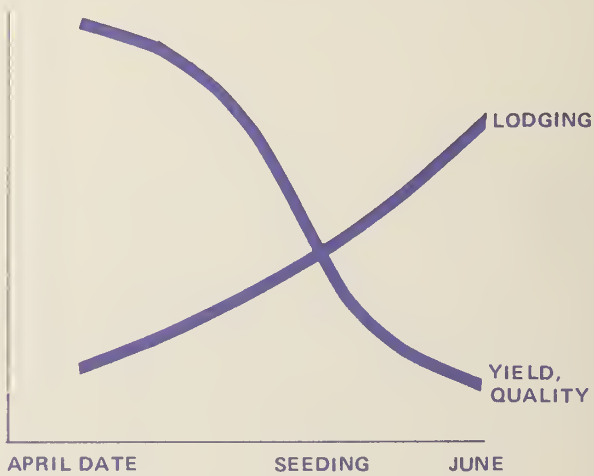
Fall preparation is the key to early seeding in the machine age!

SURFACE DRAINAGE

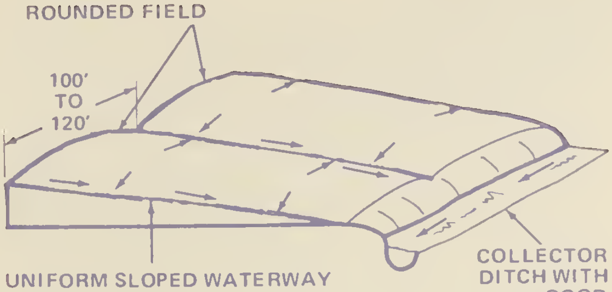
The concensus among agronomists is that subsurface drainage is the answer to early seeding. This may be true for farmers seeding in mid- to late-May in Quebec, but for early April to mid-May it is questionable.

Soil freezes deeply most winters at La Pocatière. Hydraulic conductivity is reduced in a frozen soil. Even at the best of times the hydraulic conductivity of a clay subsoil is not great. In the spring, a tremendous amount of water must penetrate the profile to reach subsoil drains. The soil is already supersaturated and likely still frozen underneath. The peds are swollen reducing the size of conducting channels. Is it reasonable to expect all the snowmelt to pass a semi-permeable barrier and be conducted away by a tiny, high friction channel underground? Is it not more reasonable to remove this water at the surface?

As soon as the surface of the soil is dry it is ready to seed. Note snowbank in background in photo taken 26th April at La Pocatière.



As seeding is delayed, yields and quality decreases and lodging increases.



It is not tile drainage but surface drainage that is needed to remove the snowmelt for early seeding in Quebec (mid-April to mid-May)

AS SEEDING IS DELAYED, YIELD AND QUALITY DECREASE WHILE LODGING INCREASES

Date of Seeding	Yield lb/ac	Bushel Weight	Lodging 1 to 9
May 3	4235	41.6	3.5
May 21	3524	41.7	4.4
June 7	1803	38.4	5.3

(Top) Snowmelt patterns on sculptured slightly rounded fields.

(Bottom) Snowmelt collects in shallow ditch to be carried to collector at center of field. These fields are underdrained.

In 1970, the tiles at La Pocatière started to flow on June 12, about 1½ months too late for early seeding. It is not tile drainage that will permit early seeding but surface drainage. Tiles are not useless—they may be needed to control a high water table—but surface drainage is required for early seeding.

Often a field will be 80-90% ready to seed but the holes and low spots are still too wet to support the tractor. Yield is sacrificed on 80-90% to allow 10-20% to be seeded.

The answer is to go around the holes, fill in the low spots or form gently rounded strips 100-150 feet wide with a uniform slope toward a discharge. It is extremely important that the field be graded uniformly and that all water channels be on a uniform slope. The channels do not have to be deep as in the Richard system, but the bottom must be uniform. One only has to observe the wet spots, and winter-killing of alfalfa in low areas, to realize that fields need leveling and grading even if there are tiles.

CEREALS IN QUEBEC

What would be the effect of improved surface drainage?

Early seeded plots have demonstrated yields in excess of 2 tons of grain per acre for oats and barley at La Pocatière. Yields of 80 to 120 bushels of early seeded barley and oats have been secured on a field scale. If 80 to 90 bushels of cereals can be produced on a regular basis and 40-50 are required to pay production costs, that leaves 40 or 50 bushels clear profit.

Cereals can certainly be produced at a profit in Quebec and Eastern Canada and they are certainly far better adapted to the marginal areas than corn. Even in corn producing areas of Quebec, cereals are profitable but perhaps cannot compete in energy production every year.

Cereals can be grown for profit in Quebec if managed as well as corn. The big key is early seeding, and fall land preparation and surface drainage will permit early seeding! ■

A SCIENCE POLICY FOR AGRICULTURE

B.B. MIGICOVSKY

Le Directeur général de la recherche d'Agriculture Canada propose l'élargissement de notre conception de la recherche agricole et l'élaboration des programmes de recherche au-delà de la production, dans des domaines où il existe un besoin. Nous devons aussi continuer de résoudre avec compétence les problèmes de production à venir.

Policy for agriculture—it is a timely theme. In Canada, the role of science in the social framework has been hotly debated for the past 5 to 10 years. Many studies have been conducted and volumes have been written, we are arriving at the point where decisions are being taken, in fact, some decisions have already been made. The Ministry of Science and Technology has announced the "Make or Buy" policy with respect to industry, which in brief enables a department of government to contract out a research program to a company or a consortium of companies. It is contemplated that a similar policy will evolve with respect to universities. The details of these policies are very important and the consequences, particularly with respect to the universities must be carefully considered.

Dr. Migicovsky is the Director General, CDA Research Branch, Ottawa. This article is based on a Convocation Address delivered at University of Manitoba.

Before the Lamontagne Senate Committee started its work there appeared to be an erroneous assumption that Canada did not have a science policy. In fact, there was a distinct policy, particularly with respect to agriculture, which served Canada well. Before and shortly after World War II, most of the agricultural science research was performed in-house, by the government in the Canada Department of Agriculture and National Research Council with steadily increasing activity appearing in universities. A relatively small amount of research was conducted by industry and such is the case today.

Science policy studies noted that Canada differed from other industrialized countries such as U.S.A., U.K. and Japan in this regard, and they associated this fact with the slower rate of industrial growth in Canada. This observed correlation of research activity and industrial growth, led to the conclusion that if you forced a change in one of the variables, such as research activity, an influence would be exerted on the rate of industrial development. In my opinion, this prediction is questionable, but, if not too costly, worth a try.

Nevertheless, as a result of the Senate Committee studies and those of Science Council, O.E.C.D., and other agencies, science activity in Canada, particularly in agriculture, came under heavy criticism. This criticism was and is unwarranted. Agricultural research has served the Canadian farmers well, and continues to do so. No research organization, anywhere, has aided agricultural production to the extent that the Research Branch has in paving the way for the evolution of Canadian Agriculture. The criticism, that we did not serve secondary industry such as product utilization, market development, and sociological problems of the farming community, is valid, and obviously, a change in policy is necessary. It should be noted however, that most of the secondary industry, e.g., food processing, was and is in the hands of large foreign companies, who operate effective research establishments in their home base, outside Canada.

BROADER VIEW

The criticism, though, must be considered positively. In the face of a changing agriculture in a changing world, we must broaden our view of agricultural research. We must formulate policies, which enables expansion of research into areas where it is needed, which goes beyond production. We must also maintain capabilities to deal with the many production problems which confront us now, and will continue to arise, in the days to come.

Why, you may well ask, do we need more knowledge? Have we not accumulated a sufficient store of scientific information? The answer to the question is simple and I will give only a few of the many compelling reasons for continued and expanding research for agriculture.

Throughout the world, and in Canada particularly, contrary to popular misconception, the total amount of available arable land is distinctly limited.

Our total land area is 2.3 billion acres. Only 5 per cent or 115 million acres are presently used for intensive agricultural production. One may be impressed by talk of millions of acres. Please note the 17½ million acres of improved land in Ontario and Quebec are equal only to the amount of farm land in the state of Ohio. In terms of this region, the three Prairie provinces contain no more farm land than do Minnesota and the Dakotas. It is estimated that, with increased knowledge and wise land-use policies, we can increase the amount of land available to us by another 2 per cent or approximately 40 million acres. This would require considerable effort on the part of many disciplines such as soil scientists, hydrologists, agronomists, chemists, physicists, etc.

The challenge becomes, how can we convert poor land, into good land, or upgrade the category. If we attempt to meet this challenge, as I believe we must, it will require, considerable effort, on the part of many scientists, and wisdom on the part of those who represent society.

This challenge must be met, despite what the market requirements appear to be. In 20 to 30 years, food requirements in the world will increase threefold. I cannot see, despite marketing problems, how Canada can avoid accepting responsibility, for doing everything possible, to meet these needs. Not only must we be able to bring new land into production, we must do everything possible, to increase the productivity of land presently occupied by our farming operations. Drought resistance, cold hardiness, disease and new crop introductions, are but a few of the important problem areas which justify further effort.

Our great concern for increasing food production goes hand in hand with genuine concern for the quality of our environment.

If man is to survive in our ecosystem, we cannot accommodate the extremes, that is, extremes in

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The headquarters of the Research Branch, Agriculture Canada, is located in the K.W. Neatby Building, Central Experimental Farm, Ottawa.

environmental destruction as well as extremes in conservation. When we consider the place of mankind in nature, which is both kind and cruel, we cannot adopt an all or none philosophy. We must choose between benefit and hazard; the choice is often difficult, and science can only present the alternatives. The ultimate decision is based on ethical, social and political criteria, with input from people in all walks of life.

Furthermore, if there is anyone who is prepared to watch a child die of malaria, encephalitis, or starvation today, because of the outside chance that controlled use of pesticides, or fertilizer, *may possibly* contribute to the disappearance of the peregrine falcon in the distant future—an event we would do everything possible to avoid—I am prepared to listen to opinions based on an all or nothing philosophy. If nobody is prepared to make such an awful decision, and I doubt if there is, please riot quietly so we can get on with our work of improving the quality of life with as little as possible damage to the quality of our environment.

In any case, be assured that the only way we can overcome our ills, environmental or otherwise, is by further scientific study and research. Our errors of the past, in technology application, are due to our knowing too little, not too much, about how the world operates.

The difficult question that a science policy for agriculture must answer, is, how much for agriculture research? I have no magic formula, but I suggest this guideline for the present. We have pressing problems to solve and could employ all the highly trained talent available to us. Research is something of a gambling game in which up to now no one has lost and everyone has won. A cost benefit study reveals this clearly. For the future, we must write realistic objectives with reasonable time frames for their attainment, and be prepared to fund on that basis.

Other questions a science policy must answer, are, who decides on the objectives, what kind of research is to be done and who does it. I agree in general, with the statements of the Science Council report no. 12. That is, agricultural research must be conducted by all sectors where there is capability—universities, industry and governments. Universities are mentioned first, because here is the source of our capability. A science policy must insure a continuous availability of well trained and motivated people. In order to do this, somehow society must be able to avoid subjecting the universities to an annual, fiscal, roller coaster ride. We must find a means of financing higher education and research so that resources are adequate and stable. It may well be, that we will have to give up some of our luxuries, so that in the future, we can retain our necessities.

NEED FOR INDEPENDENCE

If and when science policy permits adequate funding of the universities, it must be arranged that universities do not lose their independence from government, be it federal or provincial. There is a danger when funding is large and direct. Universities must retain a degree of independence, which permits them to criticize their benefactors without fear of reprisal.

If and when we succeed in expanding agricultural research into all capable sectors, we will be faced with the monumental task of coordinating the effort, without hampering the imaginative activity of the individual scientist. In our political system, this task belongs in the central government, where your elected representatives speak for all the people of Canada. To ensure effective research planning and coordination, we must have a body or council which contains representations from all sectors, staffed by an effective secretariat and this council should be responsible to a Minister of the Crown via the Deputy Minister. This is where the muscle resides and the only kind of meaningful muscle these day is money. Also it provides a protective buffer between the original donor and the recipient.

A science policy should concern itself with research, classified along the lines of basic, applied, developmental, and etc. Rather, if we must classify, it should be along the lines of what we want research to do, i.e., in terms of objectives, among which, there may well be one general objective, which is to add to the sum total of human knowledge. This will enable us to include the scientist out in left field, imaginative and brilliant, who is pushing back the frontier of knowledge, and whose work cannot be placed under a specific objective. This kind of scientist must be supported, as when we attend a horse race, we place the odd bet on the long shot to win, not always on the favorite to show. ■

BIOLOGICAL CONTROL OF ST. JOHNS-WORT

P. HARRIS and D. P. PESCHKIN

L'herbe Saint-Jean ou millepertuis, *Hypericum perforatum* L., est une mauvaise herbe commune et persistante des pâturages non améliorés dans toutes les régions du Canada, à l'exception des Prairies. Elle fait une dure concurrence aux plantes fourragères des terrains non cultivés et elle est toxique pour le bétail. La répression au moyen d'herbicides est difficile et non économique. Toutefois, la lutte biologique au moyen de deux espèces de coléoptères est un moyen peu coûteux qui se perpétue de lui-même. De fait, il offre la possibilité de rayer l'herbe Saint-Jean des listes de mauvaises herbes nuisibles de la plupart, sinon de toutes les provinces.

St. John's-wort, a common perennial of European origin, tends to exclude other herbaceous plants in dry sandy, gravelly or shallow soils. In spring it produces upright leafy stems 1 to 3 feet high with a cluster of attractive yellow flowers in early summer. These stems die in late summer and in the fall the plant produces creeping stems that form a mat of foliage. The weed proliferates by rooting these creeping stems, by suckers and by numerous seeds.

Livestock with as little as 1% of St. John's-wort in their diet become restless and develop a reddened and intensely itchy skin. They rarely die but lose appetite and condition. Fortunately, St. John's-wort is usually avoided by livestock unless forage is scarce, so that the most serious loss is the reduction in the carrying capacity of the pasture.

St. John's-wort is readily controlled by cultivation but this is not practical on most areas involved. Chemical control is not a good alternative: St. John's-wort is resistant to the cheaper herbicides such as 2,4-D, 2,4,5-T, MCPA, fenoprop, mecoprop and dicamba, although top growth can be killed with 2-3 lb/acre of 2,4-D ester. This high dose is expensive and would remove many desirable herbs from the range. Even after treatments with soil sterilants such as borax and sodium chlorate, St. John's-wort germinates from seeds and is one of the first plants to reappear. Thus, on non-cropland, biological control is the most feasible solution presently available.

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THE BEETLES

Two beetles, *Chrysolina quadrigemina* and *Chrysolina hyperici* have proved themselves against St. John's-wort in Canada. *C. quadrigemina* (Fig. 1) which thrives in places that are dry in summer, is about ¼ inch long and is colored metallic blue, purple, green or bronze. *C. hyperici* prefers moist conditions, is slightly smaller and is always metallic green. Both beetles are specialized St. John's-wort feeders, and will starve to death rather than feed on plants of any other genus. Their life cycles in Canada are similar: they feed and lay eggs on the creeping foliage of St. John's-wort in the fall; they spend the winter in the soil litter and in the spring they resume feeding and laying. A single female lays up to 2000 reddish eggs about a 1/10 inch long (Fig. 1). These may hatch into larvae in the fall or remain until spring. The larvae feed on the foliage and when full grown look like small potato beetle grubs. They pupate in the soil and emerge as beetles when St. John's-wort is starting to bloom. They feed on the flowers and leaves for about two weeks and then disappear into the soil litter until the rainy season in the fall when the cycle is repeated.

Both beetles are native to Europe and were first

Figure 1 *Chrysolina quadrigemina* beetle and eggs on St. John's-wort.

used for biological control in 1939 in Australia. After a period of adaptation, *C. quadrigemina* became dominant and controlled St. John's-wort over most of the infested area in Australia. In 1943, the beetles were sent from Australia to California where *C. quadrigemina* rapidly reduced the weed on 4 million acres of rangeland to 1% of its former density. This resulted in the removal of the St. John's-wort from the noxious weed list. In 1951, the beetles were introduced from the United States into British Columbia. The latest stage on their global tour has been their transfer from British Columbia to Ontario and Nova Scotia in 1969 and to New Brunswick in 1971. One or both beetles have also been established in Chile, Hawaii, New Zealand and South Africa.

IMPACT IN CANADA

The effect of introducing 200 *C. hyperici* in 1951 to Fruitvale, B.C. is shown in Figure 2. Initially few beetles survived and the stand of St. John's-wort fluctuated annually with summer moisture. In 1957 there was a large increase in the beetle population and the weed decreased sharply over the next three years. Eventually an equilibrium was established with a low density of both beetles and St. John's-wort. This series of events was repeated in most of the release sites in the interior of British Columbia, although the lag period before the beetles increased rapidly varied from 4 to 12 years. Today the beetles are present on scattered patches of St. John's-wort over 50 miles from the nearest release site with *C. quadrigemina* controlling it in the dry sites and *C. hyperici* in the moister ones.

There are three situations in which control has not been satisfactory.

1. Shade. Where the beetles have been established, St. John's-wort, although a sunloving plant, is now largely confined to the shade with the beetles most numerous at the forest margin (Table 1). This probably contributes to a stable beetle-weed equilibrium and results in little loss of pasture.
2. Areas subject to summer frost or winter kill of St. John's-wort. At one site a flourishing colony of *C. quadrigemina* was exterminated when temperatures of 30 and 27° C were followed by —10 and —5° C on 17 May and 23 June, respectively. Winter kill of St. John's-wort, presumably caused by poor snow cover, has resulted in the death of the beetle population and resurgence of the weed from seed without beetles.
3. Small dense stands of St. John's-wort. In a few localities the beetles apparently controlled the weed so effectively that they starved themselves out of existence. The weed then resurged from dormant seed and the cycle was repeated when dispersing beetles rediscovered the site several years later.

Near Picton, Ontario, where both beetles were

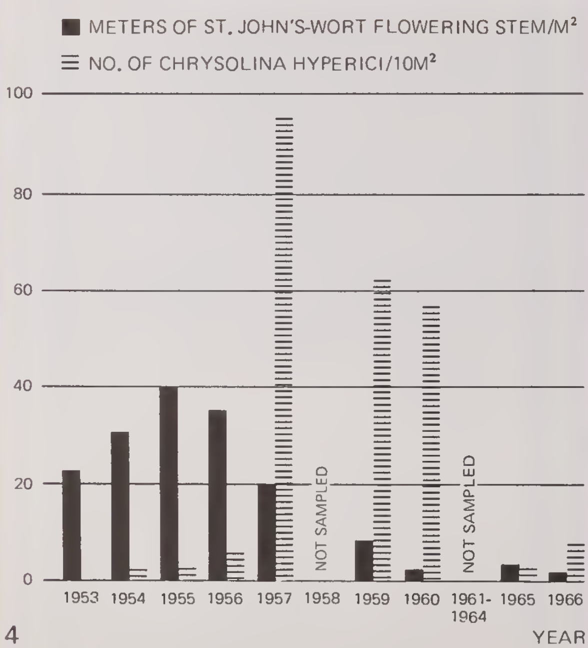

TABLE 1 DISTRIBUTION OF ST. JOHN'S-WORT AND *C. HYPERICI* AT FRUITVALE, B.C. IN RELATION TO SHADE IN 1965

	Length of St. John's-wort stem / m²	No. of *C. hyperici* / 10 m²
Unshaded	3.0 m	5.6 m
Shaded for ½ day	14.8 m	44.0 m
Shaded all day	17.2 m	6.6 m

TABLE 2 THE EFFECT OF RELEASING *CHRYSOLINA QUADRIGEMINA* AND *HYPERICI* IN 1969 ON AN UNGRAZED FIELD NEAR PICTON, ONTARIO

	Dry weight of foliage per m² in the first week in July			
Year	St. John's-wort	Forage spp.	Weedy spp.	Total yield
1970	91.4 g/m²	65.7 g/m²	16.5 g/m²	173.6 g/m²
1971	12.0 g/m²	60.6 g/m²	30.3 g/m²	102.9 g/m²
1972	0.2 g/m²	99.0 g/m²	66.0 g/m²	165.2 g/m²

Figure 2 Control of St. John's-wort by *Chrysolina hyperici* at Fruitvale, B.C.

released, St. John's-wort has been reduced to an inconsequential level. It has been replaced by a 50% increase in the grasses and legumes and a 300% increase in other weeds, mainly goat's-beard (Table 2). Meadow goat's-beard is a minor problem compared to St. John's-wort as it is palatable to livestock and readily controlled by herbicides. The total yield of vegetation has remained almost constant although its previous largest component, St. John's-wort, has almost disappeared.

St. John's-wort declined by 40% in the release area in Nova Scotia (Table 3). Climatic fluctuations could have this much effect on the weed, although in the region generally there has been a noticeable increase in the amount of the weed. In New Brunswick it is too soon to expect an effect on the weed.

ADAPTION TO LOCAL CONDITIONS

C. quadrigemina is native to a region extending from North Africa to Sweden and within this range the proportion of bronze coloured individuals increases with the mildness of the winter. The establishment of *C. quadrigemina* from California in British Columbia increased the proportion of green, blue, and purple beetles. This suggests that the 4 to 12 years before the individual colonies in British Columbia increased rapidly was a period of selection for the new conditions. The most important changes were probably that the beetles could no longer breed over winter and were killed by frost if they remained exposed on the foliage. This is supported by laboratory tests that showed the beetles from British Columbia were more inclined to seek shelter as the temperature approached freezing than those from California.

The suitability of *C. quadrigemina* from British Columbia and from California for winter survival in Ontario was tested by confining beetles from both regions to adjacent cages in a field at Picton, Ontario. The cages were banked with earth to increase winter protection. Twice as many beetles from British Columbia survived as from California (Table 4). This is further evidence that there has been an adaptation to cold winters in British Columbia. The results also suggest, as the beetles adapt to local conditions, that the best stock for redistribution will be from the same climatic region. In other words beetles from the colony in Ontario should be used to found new colonies in the Province rather than stock from elsewhere.

In a second test, the survival of *C. quadrigemina* and *C. hyperici* from British Columbia were compared in Ontario, as in the previous test, except that no attempt was made to increase winter protection. On a percentage basis *C. hyperici* was three times as hardy and its eggs twice as hardy as *C. quadrigemina* (Table 4). However, in other respects *C. quadrigemina* has proved to be more aggressive. Thus, probably a mixture of both species should be distributed in Eastern Canada.

It is not difficult to establish new colonies. The beetles can be easily collected with a sweep net or shaken into a bag in early summer when they are feeding on the St. John's-wort bloom. Collections of about 200 beetles, liberated on dense, unshaded St. John's-wort about 50 miles apart, should be sufficient to inoculate new areas. Initially there will be enough beetles to start only a few new colonies a year but increase of the new colonies within 3 years should reduce the shortage.

WHAT NEXT . . . . . ?

It has been shown that St. John's-wort can be controlled on uncultivated land by *C. quadrigemina* and *C. hyperici*. Therefore, the next step should be to distribute the beetles to areas wherever St. John's-wort causes damage.

The question is how should this be done as there is no set procedure for distribution of proven biological control agents. They could be distributed by the biological control section of the Research Station Regina although this would present a logistics problem. Another alternative is for provincial departments of agriculture to distribute the insects through their weed control specialists or agricultural representatives. This would ensure that there is local participation and that the release could be made with a knowledge of the ecology and development plans for the region. In provinces where the weed does not warrant the effort of distribution of the control insects, it should be removed from the noxious weed list. ■

TABLE 3 THE EFFECT OF RELEASING *CHRYSOLINA QUADRIGEMINA* AND *C. HYPERICI* IN 1969 ON AN ABANDONED FIELD NEAR SCOTSBURN, NOVA SCOTIA

Year	No. of flowering stems of St. John's-wort
1970	$5.8/m^2$
1971	$5.1/m^2$
1972	$3.4/m^2$

TABLE 4 WINTER SURVIVAL OF *CHRYSOLINA* SPP. IN ONTARIO

	C. quadrigemina ex California	beetles[1] ex B.C.	*C. quadrigemina* Beetles	ex B.C.[2] Eggs	*C. hyperici* Beetles	ex B.C.[2] Eggs
Winter survival	14%	31%	6%	30%	19%	63%
No. tested	72	163	110	63	70	93

[1]Cage banked with earth to enhance winter protection
[2]No winter protection provided

JEAN-LOUIS DIONNE

ENGRAIS CHIMIQUES ET POLLUTION DES EAUX

Under high fertility conditions at Lennoxville, leaching by drainage waters is more extensive for potassium than for nitrogen and phosphorus. Under normal farming conditions nutrient losses are believed to be lower, and not a serious pollutant.

La cote d'écoute des alarmistes de la pollution est à son plus haut ces années-ci. Tout ce qui touche de près ou de loin ce sujet devient rentable pour la presse, la radio et la télévision. Les cultivateurs sont régulièrement accusés de polluer les rivières et d'y empoisonner les poissons en y déversant des tonnes d'azote, de phosphore et de potasse à la suite d'épandage d'engrais dans leurs champs. Les chiffres donnant une mesure exacte de la grandeur du phénomène de la pollution se font infiniment plus rares que les articles de presses sur le sujet.

A la Station de recherche de Lennoxville, une expérience sur la fumure massive des pâturages s'est poursuivie de 1969 à 1971. Une des parcelles de l'expérience a reçu 3363 kg/ha de 10-10-10. Un drain sortait tout près de la parcelle de 0,40 hectare pour se déverser dans un fossé. Celui-ci à son tour se jetait dans un ruisseau, lequel rencontrait la rivière St-François à environ 1,5 kilomètres plus bas. Les échantillons d'eau ont été pris dans le fossé, à la sortie du drain, à quelque 50 mètres de la bouche du drain et au confluent du fossé et du ruisseau. Ensuite à 450, 1100, 1460 et 1525 mètres. Le dernier point se situait dans les eaux de la rivière St-François. La carte ci-jointe montre les sites de prélèvement d'échantillons d'eau (figure 1). Les points 1 et 2 indiquent le site des prélèvements témoins. On y a dosé l'azote nitrique $N\text{-}No_3$, l'azote ammoniacale $N\text{-}NH_4$, le phosphore inorganique soluble P, et le potassium K.

L'examen du tableau 1 révèle que l'eau de drainage a été influencée par la forte fertilisation (site n° 3) et contient beaucoup plus d'azote, de phosphore et de potassium que celle du ruisseau à 820 mètres en amont de la bouche du drain (site n° 1). A cet endroit, le ruisseau coule dans un bois et se soustrait à toute source de pollution agricole. La concentration y était au moins 5 fois inférieure qu'à la sortie du drain. Ces eaux contenaient de 0.1 à 1.5 ppm de $N\text{-}NO_3$, de 0.1 à 1.9 de $N\text{-}NH_4$ et de 0.23 à 1.4 ppm de P.

Au confluent du fossé transportant les eaux de drainage et du ruisseau coulant vers la rivière St-François (site n° 5), on a enregistré une diminution appréciable de la teneur en éléments nutritifs.

Cette dilution s'est accentuée à mesure qu'on s'éloignait puis pour enfin, à 1100 mètres en aval (site n° 7), être comparable à celle mesurée à 450 mètres en amont du drain où l'effet de la fumure massive ne pouvait se faire sentir. L'eau, en ces endroits, est quand même influencée par la fumure normalement appliquée aux sols de la ferme et sa teneur en éléments nutritifs n'est que légèrement plus élevée que celle de l'eau échantillonné en plein bois. C'est là une indication qu'une fumure normale n'accroît pas tellement la concentration en NPK des cours d'eau. Cependant, si l'on triple les quantités d'engrais épandu par une application de 136 kg/ha de N, P_2O_5 et K_2), l'excédent de ces éléments enrichira les eaux de drainage d'une façon excessive. Selon la «Royal Commission on Sewage Disposal», une eau réellement polluée contient environ 6.7 ppm d'azote ammoniacale et 5 ppm d'azote nitrique. Nos chiffres n'approchent pas ces valeurs même lorsque l'eau a été dosée à la bouche du drain sortant du pâturage fortement fertilisé.

La fumure massive a laissé le sol riche en nitrate ($N\text{-}NO_3$), phosphore assimilable (méthode de Truog) et en potassium échangeable comme on peut le voir au tableau 2. En septembre, on a remarqué que la teneur en éléments nutritifs (N, P, K) s'est accrue jusqu'à une profondeur de 61 centimètres, ce qui dénote la présence d'un mouvement des éléments fertilisants vers le sous-sol et éventuellement dans les eaux de drainage. Ce mouvement est anormal considérant l'énorme quantité d'engrais épandue à la surface du pâturage.

Lorsque l'on parle de pollution causée par l'emploi des engrais chimiques, on ne doit pas perdre de vue le rôle joué par les plantes. Nul n'épand des engrais en vue de polluer les cours d'eau mais bien pour maximiser le rendement et la qualité des plantes. Dans le cas présent, le rendement des pâturages en

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matière végétale déshydratée s'est chiffré à 11,522 tonnes/ha. Il s'agit là d'une très forte production herbagère. La teneur de l'herbe en N, P, K a été singulièrement élevée (voir tableau 3), sans toutefois que le contenu en $N\text{-}NO_3$ soit toxique pour les animaux. Le seuil de toxicité se situe, selon Marty, entre 0.3 et 0.7% de $N\text{-}NO_3$. La quantité d'azote et de potassium prélevée par les graminées (tableau 3) a dépassé l'apport annuel au sol. Le prélèvement de phosphore équivaut au tiers de la quantité annuellement appliquée. Évidemment, les plantes ont extrait du sol des éléments nutritifs qui s'y trouvaient déjà avant l'épandage mais il n'en reste pas moins qu'une grande partie du N, P, K appliquée au sol a été assimilée par le sol comme on peut le déduire par l'examen du tableau 2. Enfin, il est indéniable qu'une fraction des éléments nutritifs confiés au sol s'est écoulée. Le dosage de l'eau à la sortie du drain nous a donné une idée de l'amplitude de ces pertes en éléments nutritifs (tableau 1). Ceci constitue une mise en garde contre les applications massives d'engrais. Cependant, le fait que la concentration des eaux du ruisseau drainant le reste de la ferme fertilisée à doses moyennes soit relativement peu élevée en éléments nutritifs nous permet d'affirmer que l'usage normal des engrais chimiques ne pollue pas l'eau au point de s'en alarmer. D'ailleurs, l'augmentation de rendements résultant de la fertilisation modérée du sol compense largement pour un certain enrichissement des eaux en éléments nutritifs à la suite d'apport d'engrais. ■

TABLEAU 1 TENEUR DES EAUX EN ÉLÉMENTS NUTRITIFS

Sites d'échantillonnage[1]	$N\text{-}NO_3$ ppm	$N\text{-}NH_4$ ppm	Phosphore ppm	Potassium ppm
1	0.42	0.30	0.042	1 82
2	0.68	0.44	0.058	2.18
3	2.58	1.94	0.284	37 02
4	2.37	1.30	0.221	52 37
5	1.23	0.91	0.161	17.00
6	0.71	0.50	0.070	4 46
7	0.71	0.44	0.080	3 67
8	1.34	0.52	0.060	5 73
9	1.03	0.32	0.056	4 11

[1] Pour identification des sites, voir figure 1.

TABLEAU 2 TENEUR EN ÉLÉMENTS NUTRITIFS DU SOL RECEVANT UNE FUMURE MASSIVE

	Mai 1970			Septembre 1970		
Profondeur en cm	Phosphore pp2m	Nitrate pp2m	Potassium pp2m	Phosphore pp2m	Nitrate pp2m	Potassium pp2m
15	200.0	40	276	245.6	92	351
30	211.2	48	193	200.0	70	271
45	110.4	36	198	175.2	54	309
60	74.4	20	192	148.8	48	238

TABLEAU 3 TENEUR ET PRÉLÈVEMENT EN N, P, K DES GRAMINÉES PROVENANT DU PÂTURAGE À FUMURE MASSIVE

Eléments	Graminées—11,522 tonnes/ha		Apport au sol kg/ha
	Teneur en %	Prélèvement en kg/ha	
Azote (N)	3.08	355	336
Nitrates ($N\text{-}NO_3$)	0.062	—	—
Phosphore (P)	0.383	44	147
Potassium (K)	3.28	378	279

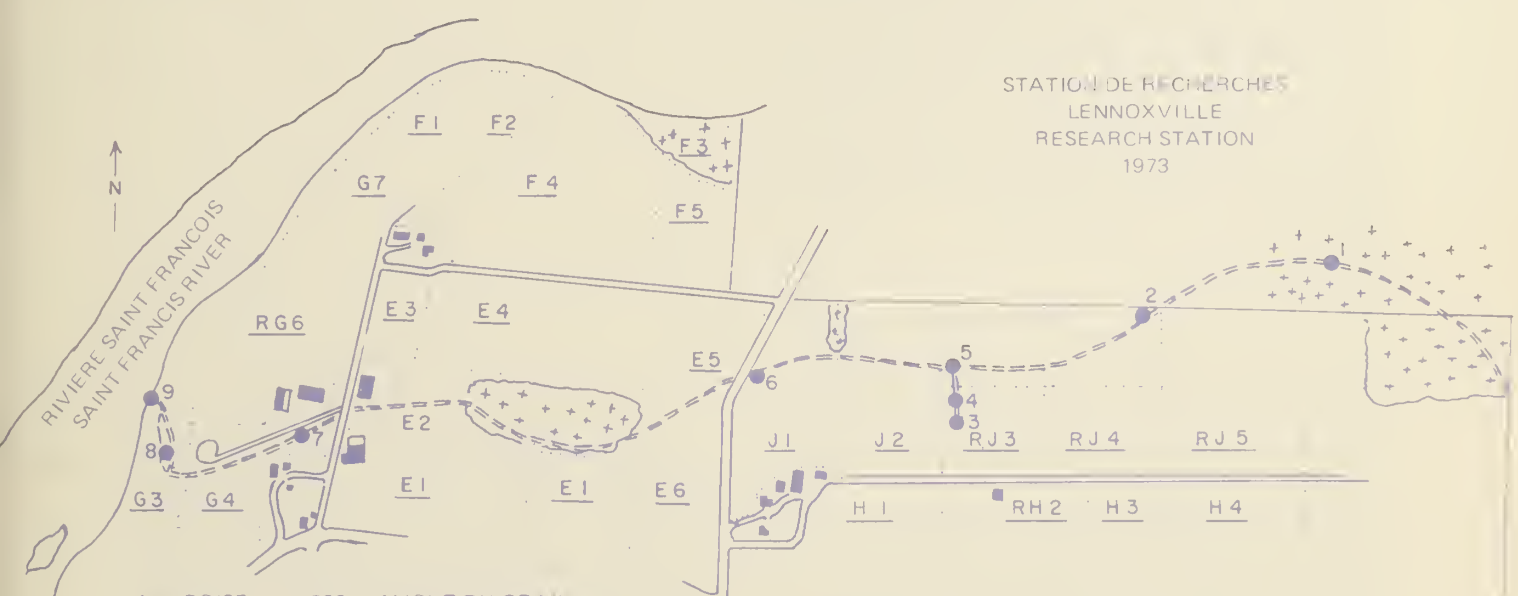

Figure 1 Carte montrant les sites d'échantillonnage de l'eau

N. D. HOLMES

Les entomologistes du ministère de l'Agriculture du Canada soulignent les problèmes économiques et de l'environnement que les insectes ont causés dans le secteur agricole. Pour un certain temps encore, les insecticides seront notre principal moyen de protéger les cultures et les animaux contre la plupart des insectes car les autres modes de lutte n'ont connu qu'un succès limité.

Whether or not insecticides should be used requires a consideration of the balance between their costs and benefits. One cost to consider is the damage insecticides might cause to the environment. The values placed on this potential damage by the public tends to vary. In Edmonton, pressures for insecticidal control of mosquitoes showed that the public was prepared to ignore possible environmental damage in return for relief from mosquito bites. People in countries where malaria is a constant threat consider the possible hazard from the use of DDT is of little importance.

The benefits of insecticides often are difficult to calculate because a measurement is required of the amount of damage the insects might have caused if they had not been controlled. But obviously an accurate measurement can never be obtained.

We can estimate the losses that some insects cause, however. In livestock, 11 grubs per animal can cause a loss worth $9.00 that can be prevented by 65 cents worth of insecticide. An insecticide at $6.00 per acre will save $1.20 per acre of sugar beets heavily infested with root maggots. An acre of wheat can be protected against 90 percent of the damage by wireworms for 15 cents.

INSECT DAMAGE

In Canada over 900 different species of insects, mites, and ticks have been reported as pests. About 600 attack annual crops; the remainder attack livestock, humans, trees, fruits, stored products, and fibres. In addition to known insect pests, others are constantly appearing. In southern Alberta, for example, three new ones appear every five years.

Changes in crops affect insect populations. The increase in rapeseed acreage was accompanied by notable increases in 22 species of insect pests. One of them, the bertha armyworm, attacked over one million acres of rape on the prairies in 1971. Infestations reaching 400 larvae per square yard were capable of destroying 10 percent of the crop in one hour.

Dr. Holmes is Head, Crop Entomology Section, CDA Research Station, Lethbridge.

Changes in weather also can produce outbreaks of many pests. One group of these pests, the grasshoppers, have infested 52.8 million acres of prairie crop land in one year. They have been so thick in Saskatchewan that, had they not been controlled, they would have consumed 83 million tons of green plants. Alberta would have lost the production from an average of 1 million acres of crop land each year of a 10-year period if the grasshoppers had not been controlled.

In Alberta in one year the redbacked cutworm has seriously damaged crops on 250,000 acres, and the corn leaf aphid has destroyed 9 million bushels of

INSECTICIDES AND CANADIAN AGRICULTURE

barley. Blackflies in northern Alberta and Saskatchewan have killed cattle. Apples in the Maritimes must be treated with insecticides to produce a marketable crop. The spruce budworm has killed as much as 20 million cords of fir and spruce in New Brunswick.

Even unobtrusive insects can be damaging. The tiny flea beetles can reduce the yield of rapeseed by 24 percent and hornflies can slow the growth of immature cattle by 20 percent.

The presence of insects alone, however, is not enough to determine when protection is required. We must know whether or not they will cause economic losses.

Most insects do not signal the economic threshold. A heavy population of grasshoppers might require control only if the spring weather is hot and dry. A heavy infestation of corn leaf aphids will severely damage a barley crop only if they attack before the boot stage.

CONTROL OF INSECTS WITHOUT INSECTICIDES

Some insect-resistant crops have been developed. The use of parasites, predators, and diseases has had limited success. The sterile male technique has been used on the codling moth in British Columbia. Insect sex attractants are being used against some pests and juvenile hormones and anti-feeding compounds also are being investigated. Cultural methods are useful for controlling some species. But, for the foreseeable future, insecticides will remain our major means of protecting crops and animals against most insects.

THE NEGATIVE SIDE

The advantages of insecticides, their availability, low cost, and rapidity of action, can lead to careless and unnecessary use. They affect many more living organisms than the particular pest against which they may be used. In nature, living things occur within complex organizations known as webs of life or food chains. Any change in the environment, as by the adding of an insecticide, sometimes affects the webs more seriously and unexpectedly than the casual insecticide user can foresee.

Many insects have developed resistance to insecticides. Some insecticides persist too long in the environment and for that reason are no longer used. Few, if any, insecticides are sufficiently selective.

In the U.S., cotton growers regularly spent $150 million per year on insecticide. By 1963, every major cotton pest had developed resistance to insecticides: 40 years of insecticide use had not solved the pest problems. The cotton problem is not unique. The success of insecticides depends on the development of the succession of new products to counter the development of resistance.

THE BALANCE

Although insecticides affect the environment, the damage they have caused to date is outweighed by their demonstrated ability to protect against insect pests. The variety of pest species, the amount of damage they cause, and the need for protection against sudden and massive insect attacks make insecticides essential. Continuing research is providing new chemicals and techniques that are reducing the potential for detrimental effects, and as a consequence of experience and new technology, the short and long term effects of insecticides and other pesticides are being identified more specifically. At the same time, we are able to obtain more effective control over undesirable side effects while retaining the benefits from their use. ■

ECHOES
FROM THE FIELD AND LAB

Chris DeWitt's covered-in horizontal silo measures 160 feet long and 45 feet wide. Filled to a depth of 12 feet it has capacity for 1700 tons of silage.

JUMBO SILO—HORIZONTAL STYLE Twenty years ago, grassland programs were coming into vogue. The North Okanagan Green Pastures Competition was organized at that time. It's still going strong under the guidance of Arnold J. Allan and Ted Berry, District Agriculturists at Vernon and Salmon Arm respectively.

But things have changed. Judging the 1973 North Okanagan Green Pastures and Corn Competition, Dr. S. Freyman, Plant Scientist, CDA Research Station, Lethbridge, Alta., noted that farmers still have to squeeze every ounce of digestible energy from the land, and that means a complete forage system including silage, hay, corn, and storage space.

Among changes observed over the years in the North Okanagan were; larger dairy herds, better management of improved forage species, larger acreage under irrigation, increased use of fertilizer, larger acreage of corn, development of land in the interior by farmers crowded out of the Lower Fraser Valley. It all adds up to more efficient production and the need for more space to store forages.

As it happened, the Grassman of the Year, Chris DeWitt of Sicamous, had the ultimate in roofed-in horizontal silos. (See photo). One hundred and sixty feet long and 45 feet wide, this jumbo had a capacity for 1700 tons of silage, or space to entertain all the citizens of Sicamous if the situation required it. DeWitt plans to fill the silo with corn silage and surplus grass from well fertilized, irrigated pastures, and he hopes to avoid a lot of sloppy work when feeding out. Productivity was estimated at 1.95 acres per animal unit on this dairy farm with 70 mature cows.

NEWFOUNDLAND POTATO SEED PRODUCTION A 1,000 acre potato seed farm is being set up in central Newfoundland and should produce some seed for Newfoundland farmers in 1974, CDA Production and Marketing officials in St. John's report. The recently approved seed farm is part of phase III of the Atlantic Regional Development Association (ARDA) program. The provincially-owned and operated farm is being set up to supply Newfoundland farmers with top quality line of disease-free potato seed stock. Operated in cooperation with the Canada Department of Agriculture, the farm will exist under strict quarantine regulations. All public visits will be prohibited and hunting, fishing, skidooing and other outdoor activity will not be permitted within the reserve. All authorized personnel visiting the station must go through a complete disinfection procedure. The Department hopes the station will be in full production by 1975. At present, Newfoundland is only producing 20 percent of its annual potato consumption of 100,000,000 pounds.

KEEPING CLEAN Of 155 grain ships inspected at Thunder Bay last year by CDA Plant Protection officials, five had to be sprayed and four fumigated before they could be reloaded. Victor Bel, an inspector with the Plant Protection Division examines ships and decides if they need cleaning, spraying or fumigating. If fumigation is required a local pest control firm is called in to handle the treatment. The ship's crew is taken off, put in a hotel and a guard placed at the foot of the gangway to prevent anyone from boarding the ship. Methyl bromide is released into the holds, and the holds are sealed for 24 hours. The gas is dangerous because it is odorless and colorless, but it also reaches hard-to-get-to places where pests lurk. Trained personnel using gas dectectors finally look for and eliminate pockets of trapped gas before permitting the crew back on board. These precautions help keep the grain freighters moving and ensure that the cargo arrives in good condition.

EDIBLE, NUTRITIOUS MATERIALS FROM WASTE Mountains of "waste" are generated daily as a result of global food production observes Ben Berck, Research Scientist, CDA Research Station, Winnipeg, and Chairman, Manitoba Environmental Research Station. Much of the waste material is dumped, buried, put into lagoons for partial biodegradation, or incinerated, discharged into industrial effluents or into air as dusts. Such treatments cost money, and causes stress on the ecology through possible contamination of the water tables, soil, air. Mr. Berck suggests that reclaiming edible materials from many wastes that currently are available must be undertaken as a positive approach to combat pollution and improve the human environment. He sees possibilities for reducing the cost of animal feeds and improving their quality by blending waste materials from food processing industries.

As an example, he calculates that Canada's 620 million bushel estimated wheat crop will contain cereal wastes amounting to about 50 million bushels of dockage (foreign matter, chaff, weed, seeds, broken kernels, etc.). The dockage is readily pelletized and mixed with other wastes for use as animal feeds, and is excellent base material for blending a wide range of edible, nutritious materials.

INFLUENCE DE LA MOTONEIGE SUR LE SOL ET LA FLORE AGRICOLES La motoneige a connu au cours des dernières années une croissance remarquable, aussi bien en nombre qu'en popularité. Toutefois, cette croissance rapide ne s'est pas faite sans soulever certains problèmes d'ordre écologique. Pour certains, la motoneige leur a permis de redécouvrir les charmes de l'hiver. Pour d'autres, elle est une machine infernale qui me-

ECHOS
DES LABOS ET D'AILLEURS

nace l'homme, la vie animale et végétale.

La Compagnie Bombardier Ltée, Valcourt, Québec, est depuis longtemps consciente des conséquences probables que puisse entraîner la pratique de ce sport sur l'environnement agricole. Depuis l'hiver 1971-72, la Station de recherches de Lennoxville a accepté de collaborer avec cette entreprise pour évaluer les effets néfastes possibles du passage des motoneiges sur le sol et la flore agricoles.

On tentera donc de déterminer dans quelles proportions la motoneige affecte les propriétés thermales de la neige et du sol, d'évaluer le comportement physiologique et le pourcentage de survie de certaines graminées et légumineuses immédiatement en dessous d'une piste. Enfin, on veut mesurer son influence sur la flore microbienne du sol sous-jacent et sur les petits mammifères et leur milieu. Alain Pesant, CDA Station de Recherches, Lennoxville, Québec.

BLOOD TEST FOR SWINE Transmissible gastroenteritis (TGE) is a virus disease that brings death to most piglets (up to 100 per cent) infected during the first week of life. The virus enters by the mouth and strips away large portions of hair-like fibers lining the small intestine. Diarrhea and vomiting are the usual symptoms indicating a piglet is infected says Dr. G. C. Dulac, a virologist at CDA Animal Diseases Research Institute in Hull, Que.

Older pigs may also be infected by the virus, but will not show symptoms and generally will not die. Older pigs, purchased at auction, or introduced to the herd may be carriers and spread the disease. Because the disease can often pass unnoticed in older swine, a blood test was developed by Dr. Dulac, to detect past infection.

There is no practical method of treatment for piglets that contract the disease. The one thing a farmer can do to protect the coming litters is to remove the small intestine from an infected piglet, grind it up, dilute it, and feed it to sows that will farrow two or three weeks later, Dr. Dulac advises. The sows become immune and can pass this immunity to their piglets through their colostrum.

THE DO-IT-YOURSELF-CROP A recent study by a CDA economist places the onus for leadership in rapeseed production on Canada. In CDA Publication 1517, entitled Rapeseed Potential in Western Canada, W. Darcovich, Economics Branch, Ottawa, concludes that expansion of the rapeseed industry will depend largely on the expertise of Canadians in research and development. And widespread use of the crop will have to be demonstrated in this country in order to promote acceptance on export markets, particularly in relation to soybeans.

In this evaluation of the research and development of rapeseed in Canada, economist Darcovich estimates that with improvement of rapeseed's competitive position, sufficient domestic and export markets would be generated to drive the industry to a sustained production of about 7.5 million acres about twice its present size, in 15 years. This represents the maximum physical limit for rapeseed acreage in Western Canada, considering that the optimum conditions for its growth are confined to the parkbelt zone and that for sustained production rapeseed requires a rotation of proper sequence and duration.

The 42-page analysis of Rapeseed Potential in Western Canada is available from the Information Division, Agriculture Canada, Ottawa, K1A 0C7.

GOOD CLIMATE FOR GOOSE FEATHERS CDA Production and Marketing officials in Edmonton have learned from the Alberta Department of Agriculture that entrepreneurs in Charlottesville, Virginia, are on the look-out for large goose feathers. They are used to make colonial-style quill pens that are supplied to the Supreme Court of the United States, and purchased by many people and institutions in United States as well as Europe. There is a requirement for 100,000 of the largest goose wing feathers available.

Lewis Glaser, the Virginian quill pen manuacturer is particularly interested in feathers from the domestic geese raised in barn-yards in Canada because he believes the vigorous climate produces large, high-quality quills

THOSE SOW AND SOW WILD OATS! Weed scientists at the CDA Research Station, Lacombe, Alta., have observed a very substantial increase in wild oats in the past year. A number of farmers in Central Alberta grow grain mainly for feed and they have not paid too much attention to this weed. They are now concerned about the increase because they realize that yield reductions are very expensive with present grain prices. They are also realizing that some of the money they are paying for fertilizer is growing more wild oats.

RECETTES POPULAIRES À L'HUILE DE COLZA—PUBLICATION 1504 Cette publication, d'abord mise au point par le ministère de l'Agriculture de l'Alberta qui en a expérimenté les recettes, est maintenant publié par Agriculture Canada. Elle comprend des plats de résistance, des soupes, des salades, des sauces et des pâtisseries. Cette publication offre la possibilité nouvelle d'utiliser l'huile de colza à la maison encourageant ainsi cette culture industrielle importante pour les agriculteurs canadiens. La qualité et le prix en sont très intéressants. On peut obtenir des exemplaires de cette publication à la Division de l'Information, Agriculture Canada, Ottawa, K1A 0C7.

This cow has done her bit to meet the requirements of the Canadian livestock industry.

SOILS AND WILDLIFE MANAGEMENT

T. M. LORD and J. I. SNEDDON

La faune dépend en fin de compte du sol, mais sa survivance peut dépendre d'un habitat de très faibles dimensions, mais critiques. La mauvaise gestion des sols peut nuire à la faune qui en dépend, ou même l'anéantir.

All wildlife is dependent on the soil. Biological productivity in any area is the sum of the interaction of climate and soil. Man has no effective control over climate but by careful management of the soil resources he may preserve the delicate balance that exists in ecosystems involving wildlife. Widespread loss or erosion of the soil mantle experienced by ancient civilizations are obvious examples of poor resource management.

A greater awareness alone will not prevent the haphazard destruction of plants, soils and wildlife. In Canada, good planning should enable us to avoid the consequences of mismanagement. Ecosystems must be preserved for reasons of conscience, aesthetics, recreational values, hydrology, and even the conservation of potentially useful gene pools.

Proper management of prime agricultural soils is taken for granted. But what of the extensive and less studied soils of the boreal forests and the hitherto less accessible subalpine and tundra environments? Overgrazing by domestic livestock can sadly deplete winter or summer range for wildlife. Other kinds of development such as mining, forestry, or careless recreational use can seriously stress, or even destroy, the natural balance in an area and deplete dependent wildlife. Ecosystems can not be studied as closely in

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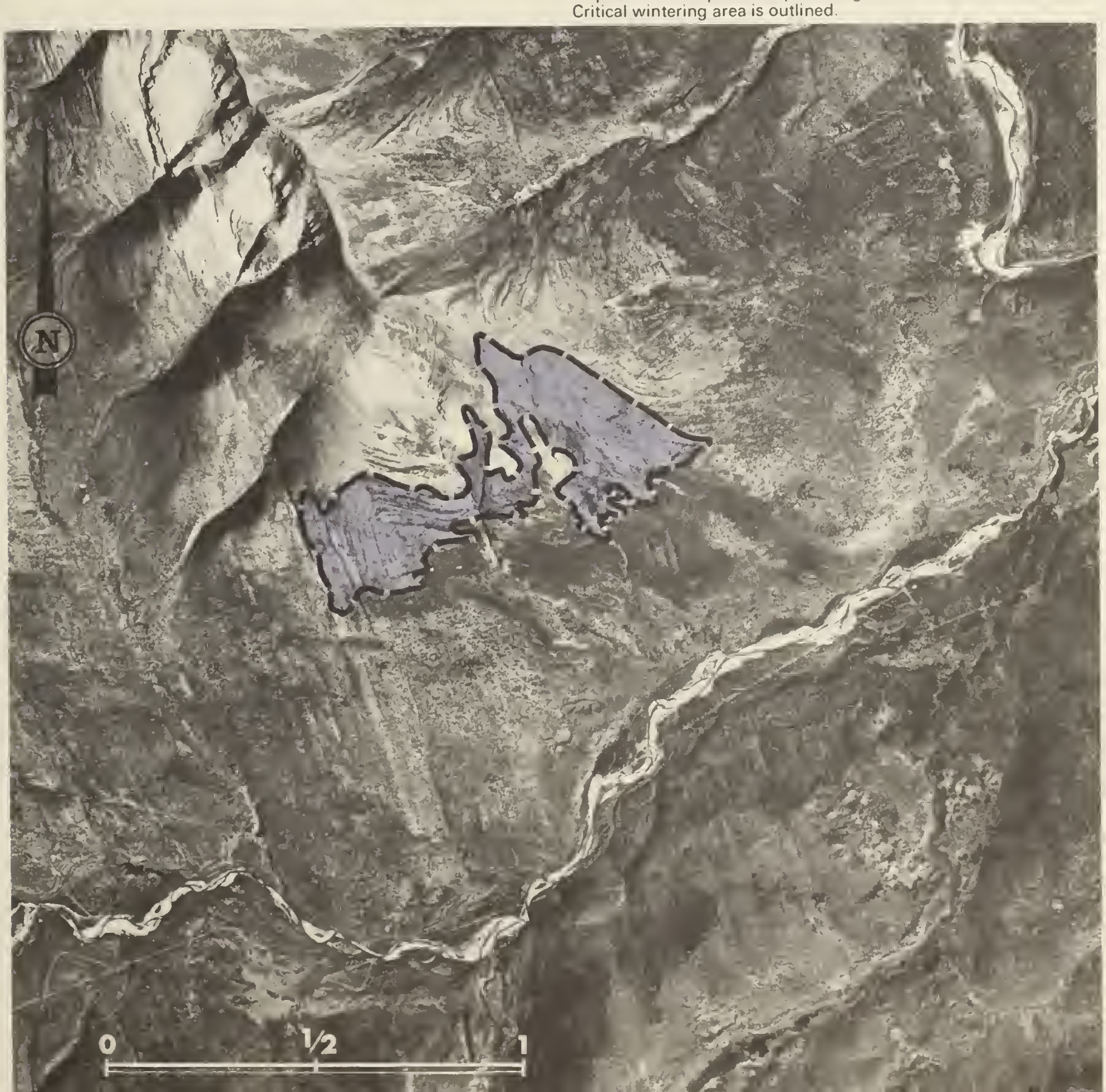
mountainous regions as they are in agricultural zones, but intensive study is possible in limited critical areas.

Soils were recently investigated in the Rocky Mountains of northeastern British Columbia in relation to the native stone sheep *(Ovis dalli stonei)*. By correlating the distribution of soil-plant communities with animal behaviour patterns it was possible to outline a definite pattern of seasonal use. Yields of dry matter from fenced plots correlated well with kinds of soils and their respective fertility levels. Thus, Black Chernozemic soils developed on calcareous materials were found to be associated with highly productive grassland communities. These biotic units, occurring on extremely steep, south and west facing alpine slopes that receive maximum heat units, comprised only four percent of the total sheep range. Yet these small units were shown to be critical. They supply almost sixty percent of the total forage wintering sheep. In summer, sheep graze these same communities, plus other less productive shrub and forb communities on basic and strongly acid soils.

The alpine ecosystem is a delicate environment for plants and animals. Once disturbed, alpine areas are slow to recover from the effects of fire, overgrazing, or other misuses. Attempts at seeding, replanting or other methods of reclamation are costly and often ineffective. As indicated earlier, sheep depend on certain soil-plant communities for their survival in winter. Disturbance or loss of these communities can result in deterioration of the population or loss of the sheep. Wildlife studies in other parts of the province have shown a similar dependence on soils and plants.

An understanding of the place of soils in the ecosystem can aid in the optimum utilization of natural resources compatible with the needs of wildlife as well as man. ■

Airphoto shows part of alpine range for about 50 stone sheep. Critical wintering area is outlined.



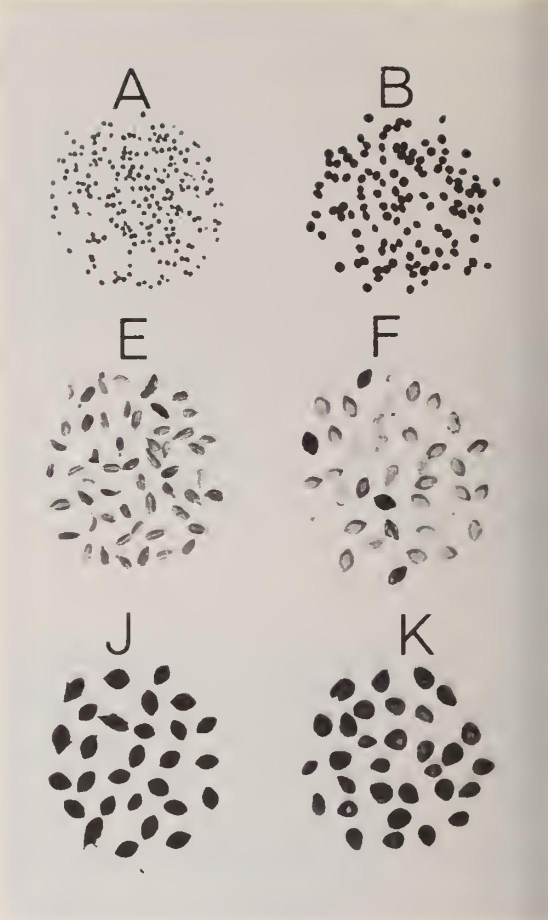


Figure 1. Typical seeds with scale—1 division equals 0.5 mm.
A. Cerastium vulgatum (Mouse ear chickweed)
B. Spergula arvensis (Corn spurry)
C. Prunella vulgaris (Healall)
D. Silene cucubalus (Bladder campion)
E. Carrot
F. Setaria viridis (Green foxtail)
G. Carum carvi (Caraway)
H. Turnip
J. Polygonum convolvulus (Wild buckwheat)
K. Galeopsis tetrahit (Hempnettle)
L. Onion
M. Tomato
N. Wheat
O. Barley
P. Oats
Q. Rye
R. Beet
S. Parsnip
T. Cucumber
U. Corn
V. Beans

SEED COUNTERS AID RESEARCH

W. S. REID

Les chercheurs exigent que les semences de toute forme et de toute taille soient comptées avec précision. Le Service de recherches techniques d'Agriculture Canada met au point des compteurs depuis nombre d'années, depuis le simple outil mécanique jusqu'aux appareils semi-automatiques perfectionnés.

Over a number of years there has been a requirement to count seeds within the Research Branch. Originally, this was limited in scope to counting corn, wheat, oats, barley. As work increased and expanded into other areas, this requirement extended to cover other commercial crops, the grasses, legumes, vegetables, flowers and weed seeds. Engineering Research Service began development of wheat seed counters in 1954, exemplified in the work of Goulden (1957). Since then, development has been continuous, and has included counters from the simplest mechanical aid, through intermediate stages to sophisticated semi-automatic units.

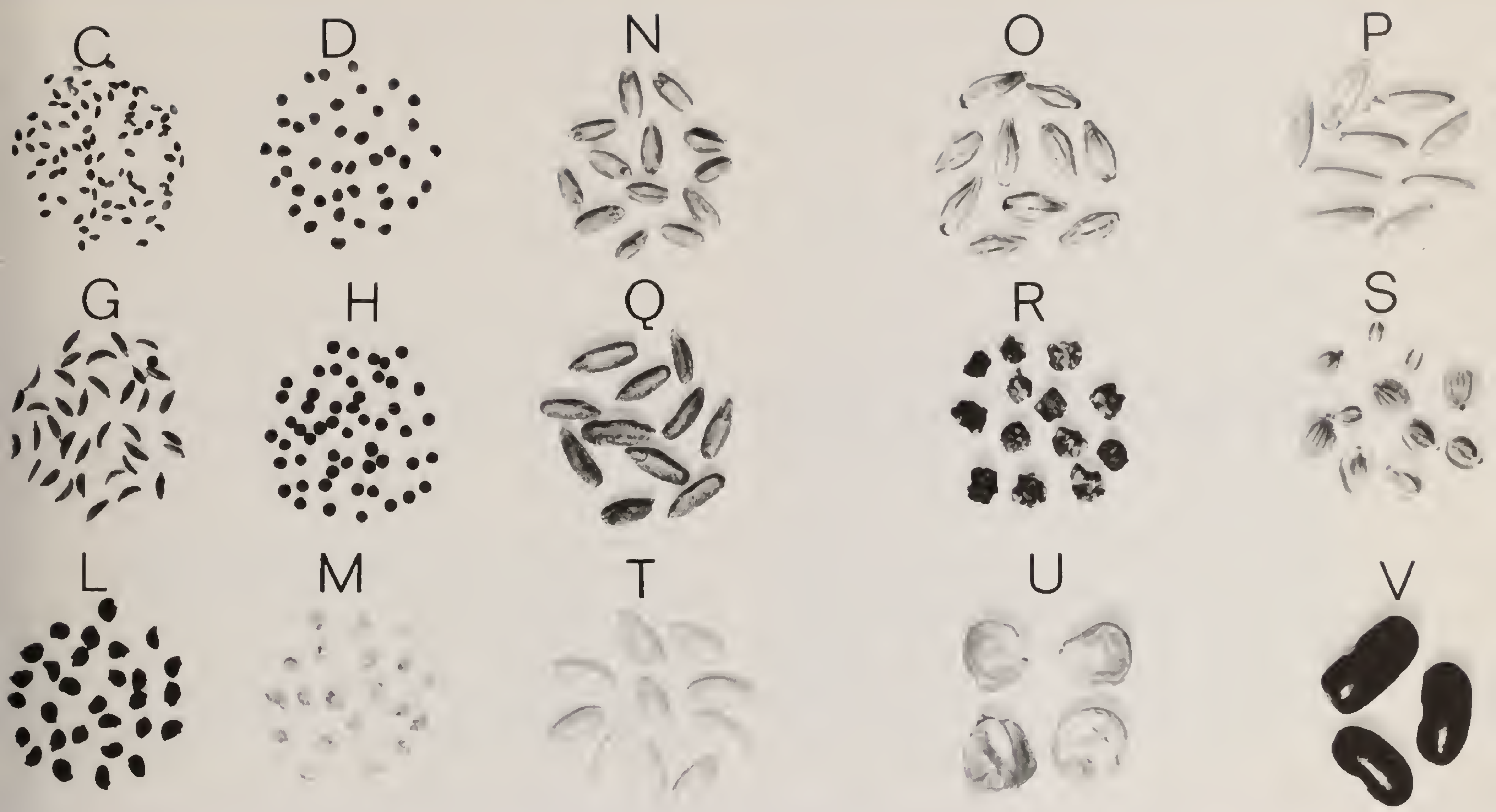
Mr. Reid is with CDA Engineering Research Services, Ottawa.

PROBLEM

In research dealing with the seeds of weeds and plants, seed sizes can vary from that of the coconut at 10-17 cm spherical diameter to tobacco which is as small as .05-.075 cm spherical diameter. Some seeds are long and thin, such as ash, which is .25 cm thick by .95 cm wide and 3.75 cm long. Some are round and flat like celery, or cylindrical like oats, some are pear shaped, or flattened pear shaped, or even banana shaped (Fig. 1). Each seed species usually varies in size by a factor of two, in one, two or three of its linear dimensions depending on its basic shape. This presents a number of problems in equipment design in terms of accuracy, complexity (i.e. range of seeds to be counted) and versatility.

One other important aspect of seed counting is the likelihood of dirt contamination, and the presence of broken or non-viable seeds that affect germination. With the smaller seeds it is not always possible to tell visually what is dirt and what is seed, similarly without a germination test the total seed count may have little meaning. In simple yield tests viability may not be important, in which case count accuracy is more important.

Other principal performance criteria are speed and



cost, although maximum speed is not usually critical unless large batches are to be counted frequently. In research the requirement may be to count specific numbers of seeds in a sample or samples (total count), or alternatively to count specific numbers of seeds from each of several samples or sample (predetermined count).

UNIVERSAL COUNTER

In the initial development stages the requirement was usually to count types of seed that could not have been counted faster and more accurately than with equipment available within the Research Branch at that time. As development progressed, the objective changed to that of designing a universal counter requiring little modification to cover all seeds.

EQUIPMENT PERFORMANCE

The limits on equipment performance are governed by the speed at which a seed or seeds can be passed by a sensor, the speed of response of the sensor, and its ability to discriminate between seeds passing by in sequence, or two or more seeds passing by or through the sensor simultaneously. The speed of the seed passing by the sensor is a mechanical problem and usually involves acceleration of the seed and some form of alignment and regimentation. For convenience, a vibrating bowl feeder with a chute or guide is usually used. The ability .to discriminate between individual seeds in sequence or two or more seeds passing simultaneously is a sensor problem and is usually electronic. For large seeds, coconuts and walnuts, for example, a mechanical sensor may be effective, but slow. Most seed counters use photo-optic sensors to detect the passing seed.

Count rate is determined most frequently by the mechanical aspects of the counter to ensure the seeds pass before the sensor in a reasonable manner. The seeds are usually allowed to drop in air, and their velocity limit is a function of their size. This lies within the range 213-487 cm/sec for the smallest and largest likely to be counted in Canada. That is from .05-1 cm in size respectively. With uniform spacing between seeds of 0.1 cm, and a maximum seed size of 0.1 cm, the smallest seeds can be counted at the rate of 60700 per min and the largest seed at 14600 per min. The electronic limits to the rate of count are governed in general by the response of the photodetector and associated circuitry and can be as high as 6 k Hz for 100% response and 80 k Hz for 50%

response which is significantly higher than the mechanical limitations.

The height to which seeds are permitted to fall is about 15 cm, so they are not likely to reach much greater than half the terminal velocity. Even at this speed, quite high count rates are theoretically feasible.

RECENT DEVELOPMENTS

Developments have included a simple hand held rapeseed counter (Fig. 2) with count rates of up to 500 seeds per minute with an accuracy of better than ± 0.5%. Simple vibrating bowl photo-optic detector counters developed by Goulden and Mason (1957) have been used for counting seeds in the barley-flax size range. Count rate is approximately 2—300 seeds per minute with accuracies of ± 1%. These developments were followed by a pneumatic pick-up rotating head counter for tobacco seed (.625—.88 mm in size), a very small seed for which alignment was considered to be a problem (Fig. 3). This machine uses a photo detector with optical light source and collimator, the seed being guided past the detector through a glass tube 1.01 mm bore. Maximum count rate is 650 seeds per minute with an accuracy of from ± 1 to ± 2% dependant on count rate.

Subsequent to the tobacco seed counter, requirements were established for a predetermining multi-sample, total count rapeseed counter and a total count weed seed counter. In these counters which were developed concurrently, the design aim was to make them suitable for universal seed counting.

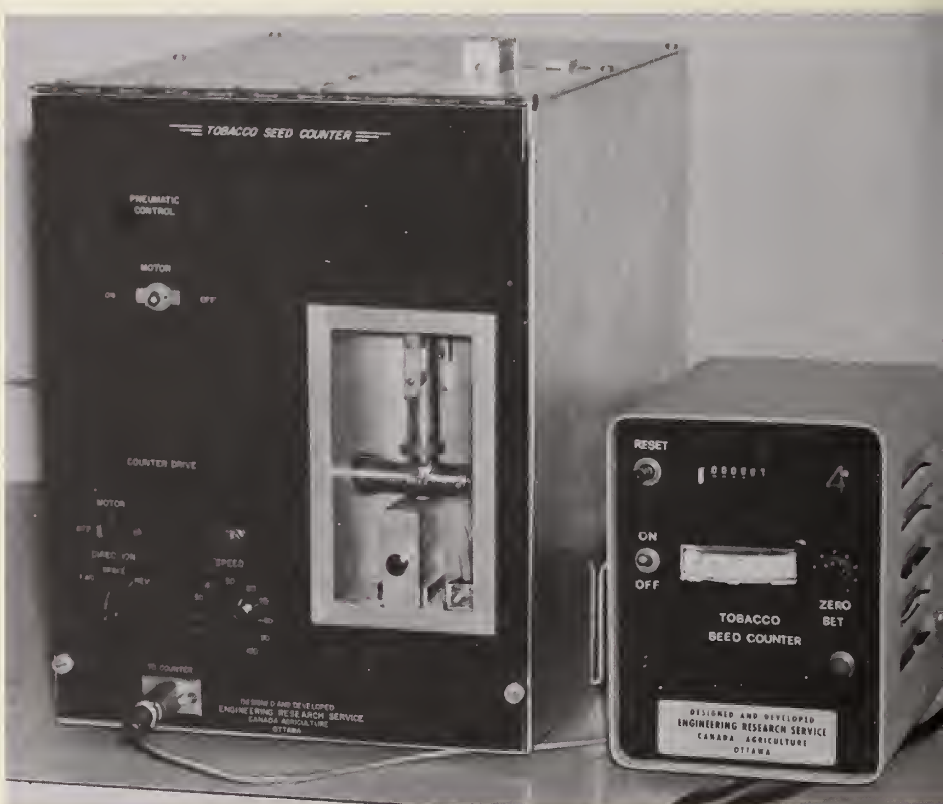
Fig. 4 and Fig. 5 show the multi-sample rapeseed counter and the weed seed counter respectively. Again each machine uses a photo-detector and light source with various sized tapered glass tubes 15 cm long to collimate the seeds through or into the beam. For small seeds less than 2 mm diameter, it is usual to focus the beam through the tube. For larger seeds the beam is focussed below the tube tip.

The features available in the multi-sample seed counter developed include single or multiple sample (23 samples), total or predetermined count, for seed sizes from .9 cm down to .8 mm. Count speeds vary from 150—300/min dependant on seed size and

Figure 2 (Left) Hand held rapeseed counter showing vacuum connection right foreground, push button, pick up and release valve top left, and countersunk rapeseed orifices in black on white plastic for visual contrast left.

Figure 3 (Below) Tobacco seed counter with pick up head assembly and electronic counter.

Figure 4 (Right) Multi-sample rapeseed counter with 23 cup ferris wheels for seed delivery and collecting, showing also the laser middle left foreground, vibrating bowl feeder centre top. On the right is the electronic cabinet with counter for total count, comparator for predetermined count and printer for each sample.



sample size, the smaller samples and larger seeds reducing count rate. Accuracy can vary from ± 1% to ± 7% with different seeds. When accuracy is required, special care can reduce this to ± 1% for most seeds.

The small weed seed counter developed has a similar range and accuracy to the multi-sample rapeseed counter and uses a low cost laser to generate a small coherent beam, with beam focussing, lateral beam spread, light collecting lens and detector similar to the rapeseed counter. This unit operates in the single sample total count mode only.

Some comment with regard to commercial equipment availability and capability is worthwhile. These units usually use optical windows with photo-optic detectors and detect a seed as a result of modulation of a random path reflected beam. This results in one major advantage for counting which is the elimination of the need to collimate the seed accurately although there is still a need to ensure they drop through the detector singly. Accuracies of ± 1% are claimed and can be as good as ± 0.25%. It is usual to have two sized detectors for large and small seeds.

Significant improvements in seed counting capability have been achieved within the Engineering Research Service, specifically in versatility and range. In terms of accuracy and speed, the possibility of improvement has been virtually exhausted with current techniques. ■

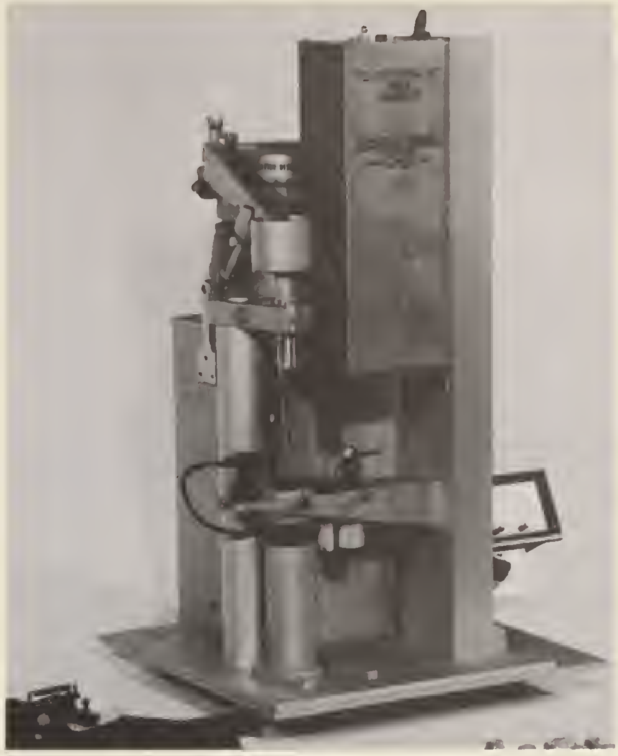


Figure 5 Universal counter designed specifically for small weed seeds using a cheap laser as a collimated light source with beam spreader and collecting lens. Various diameter tapered glass tubes are used to collimate the seed.

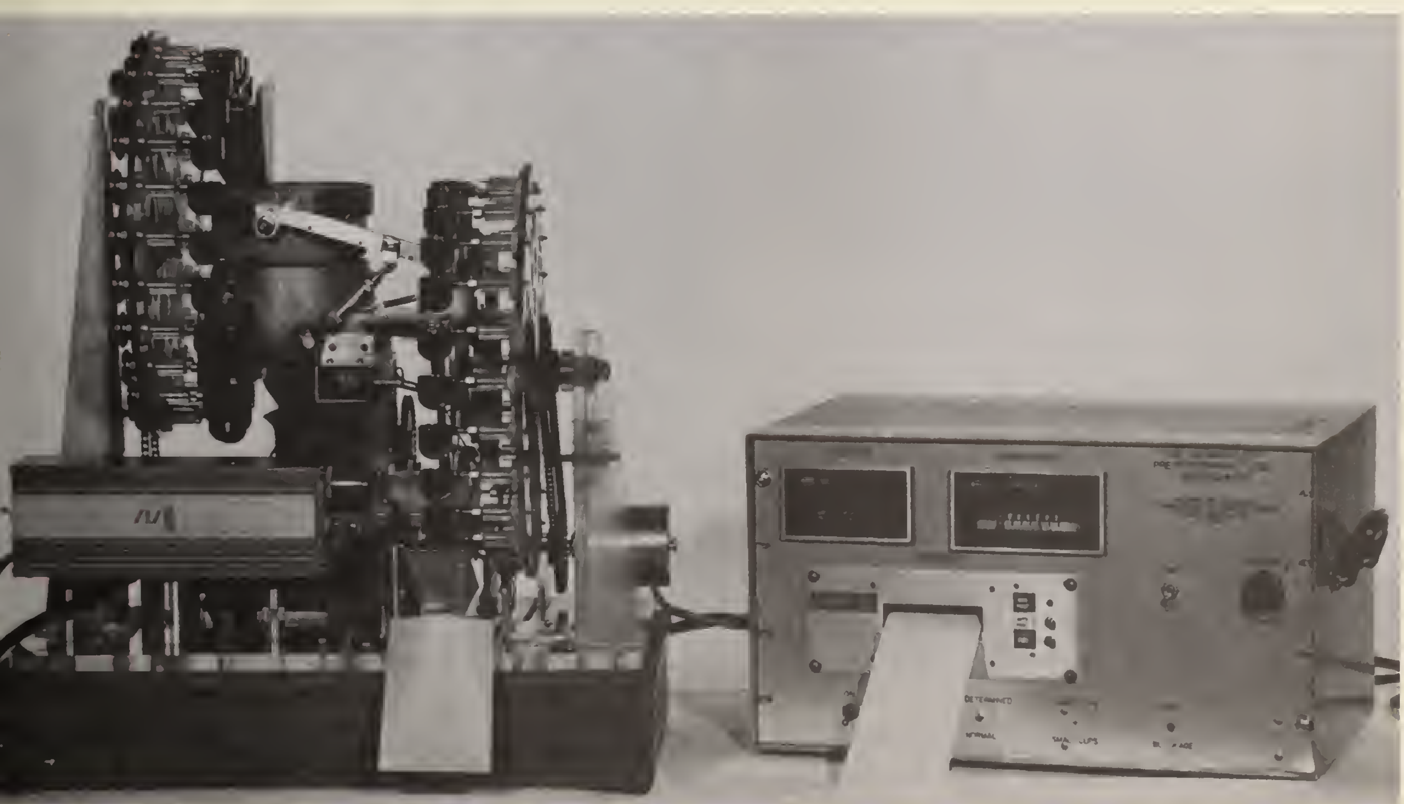


Figure 1. Look-alike diseases induced in tobacco plants
(A) tomato ringspot virus, transmitted by a soil nematode;
(B) cucumber mosaic virus, transmitted by an aphid.

SEROLOGICAL APPROACH TO VIRUS IDENTIFICATION

J. H. TREMAINE

Souvent, les maladies virales des végétaux se ressemblent mais des agents divers peuvent les répandre. Il faut donc identifier les virus qui en sont la cause afin de recommander des moyens de lutte appropriés. Il existe des méthodes sérologiques permettant d'identifier rapidement une quarantaine de virus des végétaux.

Diseases caused by plant viruses are common in a wide variety of plants and weeds that grow in Canada. Some of these diseases do little or no damage but others cause serious losses and are widespread. The plant pathologist's first task, and one of the most difficult is to identify the virus or viruses causing the disease. At the Canada Department of Agriculture Research Station in Vancouver we are studying serological methods for identifying plant viruses and now have a store of antisera for about 40 plant viruses to help plant pathologists identify them.

Identification is essential for working out controls for virus diseases since they can be spread from plant to plant in the field in various ways, some by carriers or by different vectors (Fig. 1). It is necessary to know the identity of the virus to take full advantage of information already published on the relationships between the virus, the vector, and the host plant. Some viruses occur in weeds and eradication of these sources of infection may be important.

When a plant virus is introduced into the blood stream of a laboratory animal, usually a rabbit, it causes antibodies to form in the blood serum. These antibodies possess the ability to unite with that plant virus and no other. The union of the plant virus particles with their corresponding antibodies in a test tube results in the formation of a precipitate. Other plant viruses will not react with these antibodies.

Since the introduction of any foreign protein into the blood stream of a rabbit will induce antibodies, it follows that the plant virus must be carefully purified, and separated from unwanted plant proteins. Plant viruses are purified from infected plants by methods which maintain the stability of virus particles during their separation from the great variety of particles that occur in all plants. These methods vary considerably from virus to virus and

Dr. Tremaine is in the Virus Chemistry and Physiology Section, CDA Research Station, Vancouver.

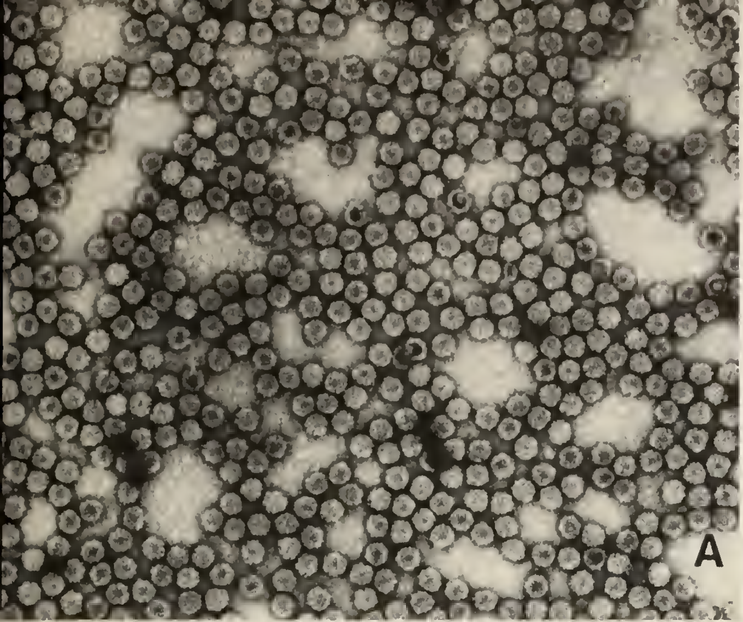
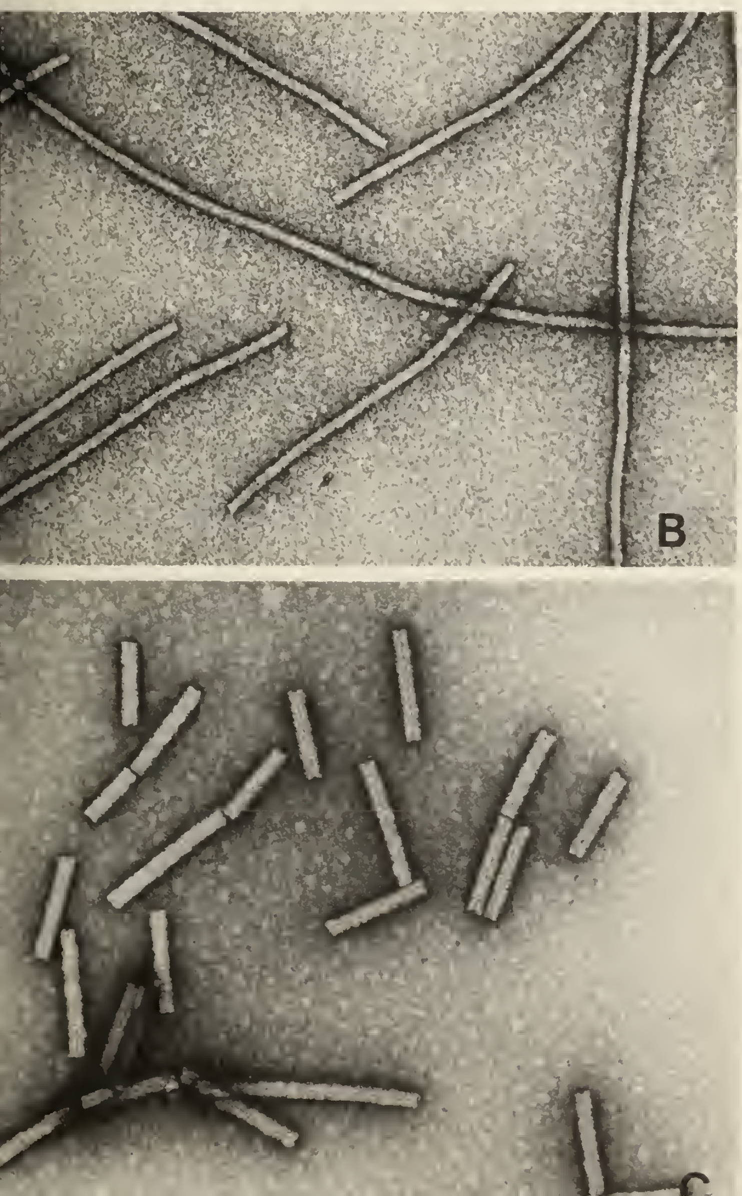


Figure 2. (A) Spherical particles of carnation ringspot virus. (B) Thin flexible rod-shaped particles of potato virus-X. (C) Stubby rod-shaped particles of barley stripe mosaic virus. The particles in these pictures are 100,000 times their actual size.

Figure 3. Serological test in agar gel between wells containing healthy plant sap (H), diseased plant sap (D), and the antiserum (A). The precipitate has formed in the agar between A and D. There is no reaction to H.



often many trials have to be made before a successful method is found.

The purity of the virus is so critical in producing antisera that rigorous tests must be conducted to ensure that the virus preparation is as pure as possible. One of these tests involves examination of the shape of the virus particles, through the electron microscope. The shape may be spherical, thin flexible rods, stubby rods (Fig. 2) or even bullet shaped. They are smaller than a millionth of an inch. Sometimes plant material can be seen in impure virus preparations.

Some plant viruses can be identified by using a small amount of sap from infected plants. With the rod-shaped viruses, a precipitate forms when the sap and antiserum are mixed in a test tube. With spherical viruses, drops of antiserum and sap are placed in separate wells cut in an agar gel and within a day a line of precipitation forms in the gel between the two wells (Fig. 3). These relatively simple methods do not work for viruses that are in low concentration in the plant and these viruses have to be concentrated before testing.

There is free exchange of antiserum among plant pathologists around the world to help identify plant viruses not previously found in a country. The Vancouver Station has supplied researchers with antiserum to identify cucumber necrosis virus, which so far has been found only in Canada. Similarly, researchers in the United Kingdom have sent antiserum to to us to identify cherry leaf roll virus which had not previously been recognized in Canada. The exchange of antisera is a safe way to avoid introducing a possibly serious virus into native crops. Antisera are not capable of causing disease themselves. ■

G. PELLETIER et F. DARISSE

FAUT-IL SEMER DES ESPÈCES SEULES OU DES MÉLANGES POUR LA PRODUCTION DE FOIN ET D'ENSILAGE?

In trials at Normandin, Que., brome-alfalfa mixtures have given the best yields. Grown singly, brome has yielded higher than timothy. It may be advantageous to grow certain high yielding forages alone, such as alfalfa, without competition from nurse crops.

La culture des plantes fourragères en vue de la production de foin ou d'ensilage se fait souvent par l'association d'une graminée et d'une ou plusieurs légumineuses. Certains mélanges s'adaptent mieux aux différents sols et climats. Il est donc important de connaître le mélange fourrager le mieux adapté à ces conditions. Toutefois, avec la possibilité d'utilisation d'herbicides lors de l'établissement des plantes fourragères, la culture des mélanges présente des difficultés. En effet, il existe très peu d'herbicides qui soient à la fois sélectifs pour les graminées et les légumineuses. Alors, quelle quantité de fourrage devons-nous sacrifier si l'on utilise une espèce seule au lieu d'un mélange? Est-ce que l'augmentation du rendement et de la qualité des fourrages compense les inconvénients qu'entraîne l'utilisation de mélanges fourragers?

Des essais, entrepris à la Ferme expérimentale de Normandin, tentent de répondre à ces questions. Du brome (Saratoga), de la fléole (Champ), de la luzerne (Saranac), du trèfle rouge (Lakeland) et du trèfle d'alsike (commercial) ont été ensemencés seuls et/ou en mélanges, sans plante-abri, en 1969 et 1970. Les mauvaises herbes ont été détruites au moyen d'herbicides. La régie de ces essais a été celle généralement recommandée pour ces espèces, sauf pour les graminées qui ont reçu une fumure azotée inférieure aux recommandations, soit une application de nitrate d'ammoniaque au taux de 80 livres à l'acre, tôt au printemps, et une autre espèce après la première coupe. Néanmoins, cette fertilisation se rapproche de celle généralement utilisée par les cultivateurs de la région du Saguenay-Lac Saint-Jean. Le mélange le plus répandu dans cette région est la fléole en association avec le trèfle rouge.

Les tableaux 1 et 2 indiquent que l'association brome-luzerne donne les meilleurs rendements. Les mélanges de fléole et de luzerne ou de fléole, luzerne et trèfle rouge viennent en second lieu pour les rendements totaux. La contribution des légumineuses aux rendements a été plus faible pour les mélanges qui contiennent du brome que pour ceux qui contien-

M. Pelletier est agronome à la station de recherches de Lennoxville (Québec) d'Agriculture Canada. M. Darisse est régisseur à la ferme expérimentale de Normandin (Québec).

TABLEAU 1 COMPARAISON DES RENDEMENTS (LB/ACRE) DE DIFFÉRENTES ESPÈCES DE PLANTES FOURRAGÈRES SEMÉES PURES ET EN ASSOCIATION (SEMIS 1969)

Espèce seule et mélange	1970	1971	1972	Moyenne de 1970-1972 2 ans
Brome 12, Luzerne 8[1]	8739	6836	7906	7827
Fléole 6, Trèfle rouge 2, Luzerne 6	8106	6436	8089	7544
Fléole 6, Luzerne 8	8197	5652	7941	7263
Luzerne 12	7496	3956	6632	6028
Fléole 6, Trèfle rouge 6	5590	4996	6213	5600
Fléole 6, Trèfle rouge 4, Trèfle d'alsike 2	5933	4624	6023	5527
Brome 12, Trèfle rouge 2	6302	4686	5478	5489
Brome 15	6706	3378	5028	5037
Fléole 8	4733	4025	6218	4992
Trèfle rouge 8	4457	3687	5339	4495
Trèfle d'alsike 6	4525	3704	3476	3902

[1] Le chiffre qui suit le nom de l'espèce indique le taux de semis en lb/acre.

TABLEAU 2 COMPARAISON DES RENDEMENTS (LB/ACRE) DE DIFFÉRENTES ESPÈCES DE PLANTES FOURRAGÈRES SEMÉES PURES ET EN ASSOCIATION (SEMIS 1970)

Espèce seule et mélange	1971	1972	Moyenne de 1971-1972
Brome 12, Luzerne 8[1]	9151	9155	9154
Brome 12, Trèfle rouge 2	9704	8172	8938
Brome 15	8625	8239	8432
Fléole 6, Luzerne 6	8572	8071	8322
Fléole 6, Trèfle rouge 2, Luzerne 6	8654	7948	8301
Fléole 6, Trèfle rouge 4, Trèfle d'alsike 2	8117	6824	7470
Luzerne 12	7128	7611	7370
Fléole 6, Trèfle rouge 6	7566	6830	7198
Fléole 8	7645	6648	7147
Trèfle rouge 8	3104	3649	3377
Trèfle d'alsike 6	2828	2294	2561

[1]Le chiffre qui suit le nom de l'espèce indique le taux de semis en lb/acre.

nent de la fléole, d'après les résultats de l'analyse botanique. A remarquer que l'addition de trèfle rouge au mélange fléole et luzerne n'a pas été avantageuse.

Parmi les espèces seules, le brome et la luzerne ont donné les meilleurs rendements, ceux-ci étant même supérieurs à certains mélanges. Le brome a donné des rendements beaucoup plus élevés que la fléole à la première année de récolte, en dépit du fait que le brome soit généralement plus difficile à établir que la fléole. L'établissement des espèces fourragères sans plante-abri aurait été favorable au brome.

Il est intéressant de noter que le brome peut donner des rendements plus élevés que le mil dans la région du Saguenay-Lac Saint-Jean bien que le brome n'était pas recommandé jusqu'à présent dans cette région aux étés pluvieux et frais. Même si la fléole semée en association avec le trèfle rouge demeure un bon mélange fourrager pour la production de foin et d'ensilage dans la région du Saguenay-Lac Saint-Jean, la culture du brome associé à la luzerne devrait se répandre. Cette pratique augmenterait les rendements des prairies et la qualité des fourrages produits dans cette région. En plus de son potentiel de rendement élevé, le brome est peu endommagé par l'hespérie européenne (*Thymelicus lineola* Ochs.) qui cause de lourdes pertes de feuillage de fléole au Saguenay-Lac Saint-Jean depuis trois ans. Il y a là un autre avantage en faveur de la culture du brome par rapport à la fléole.

Les mélanges fourragers donnent des rendements supérieurs aux espèces seules d'au moins une tonne de matière sèche à l'acre. La culture des espèces seules pourrait cependant être avantageuse, dans le cas de la luzerne quand celle-ci est établie sans plante-abri et avec l'emploi d'herbicides. ■

LITTLE CHERRY DISEASE-ONE BATTLE WON, OTHERS TO FIGHT

A. JUERGEN HANSEN

Le virus dévastateur de la petite cerise est originaire de l'est de la Colombie-Britannique. Une récente épidémie dans les principales régions productrices de cerises du centre-sud de la Colombie-Britannique a été contrôlée, semble-t-il, grâce à la coopération étroite des producteurs et des ministères provincial et fédéral de l'Agriculture. La nouvelle variété de cerise «Kootenay Bay Lambert» a résisté jusqu'à maintenant au virus.

Of the various diseases attacking plants, one group poses a particular challenge to scientists—the virus diseases. Not only are viruses so small that they cannot be detected by normal microscopical methods, but once they have infected a plant that plant will remain infected for the rest of its life. Moreover, field diagnosis of virus diseases is complicated because minor element deficiencies, winter injury, and other adverse conditions can induce very similar symptoms.

One virus disease that has been particularly devastating to the cherry industry in the Kootenay District of eastern British Columbia, is Little Cherry. It was inadvertently imported with ornamental flowering cherries in the 1930's and had been spread by insects into commercial cherry orchards. The rapid spread and disastrous effects of the disease struck an industry that was already suffering from low post-war prices. Commercial cherry production in the Kootenay declined within 20 years to 10% of its original volume. However, the bulk of the B.C. cherry production is located in the Okanagan valley in west-central B.C. and this area, 200 miles to the west of the Kootenays, remained free of the disease for many years.

When a few Little Cherry-infected trees were discovered in an Okanagan orchard in 1969, growers and plant pathologists became extremely alarmed and fears were expressed that the Okanagan cherry industry might be headed for the same fate as the one in the Kootenays. Although the disease is still not well understood, enough facts had been established to plan strategy for control.

The first step, not very original, but nonetheless essential, was the formation of a committee which coordinated the various aspects of the work: growers wanted to know the danger potential, the cooperative sales organization had to be informed, Provincial pathologists had to survey the area to determine the extent of the outbreak, and pathologists from the Agriculture Canada Research Station at Summerland backed up the efforts of the other groups by indexing suspected trees and by suggesting field control measures.

Soon it became apparent that the outbreak was restricted to a few orchards in the Penticton area, and that control by eradication might still be possible. With the cooperation of the growers involved, all affected or even suspicious trees were removed in the winter of 1969. Since Little Cherry symptoms can easily be confused with those of zinc deficiency, all remaining trees in the affected orchards had to be indexed. This meant that buds from these trees had to be budded onto small trees of the cultivar 'Sam' which develops red leaves if the disease is present.

In the summer of 1970, the Provincial Department of Agriculture, backed by the Summerland Research Station, organized a survey during which all cherry trees in the Okanagan Valley and the neighbouring Similkameen Valley were inspected at harvest time.

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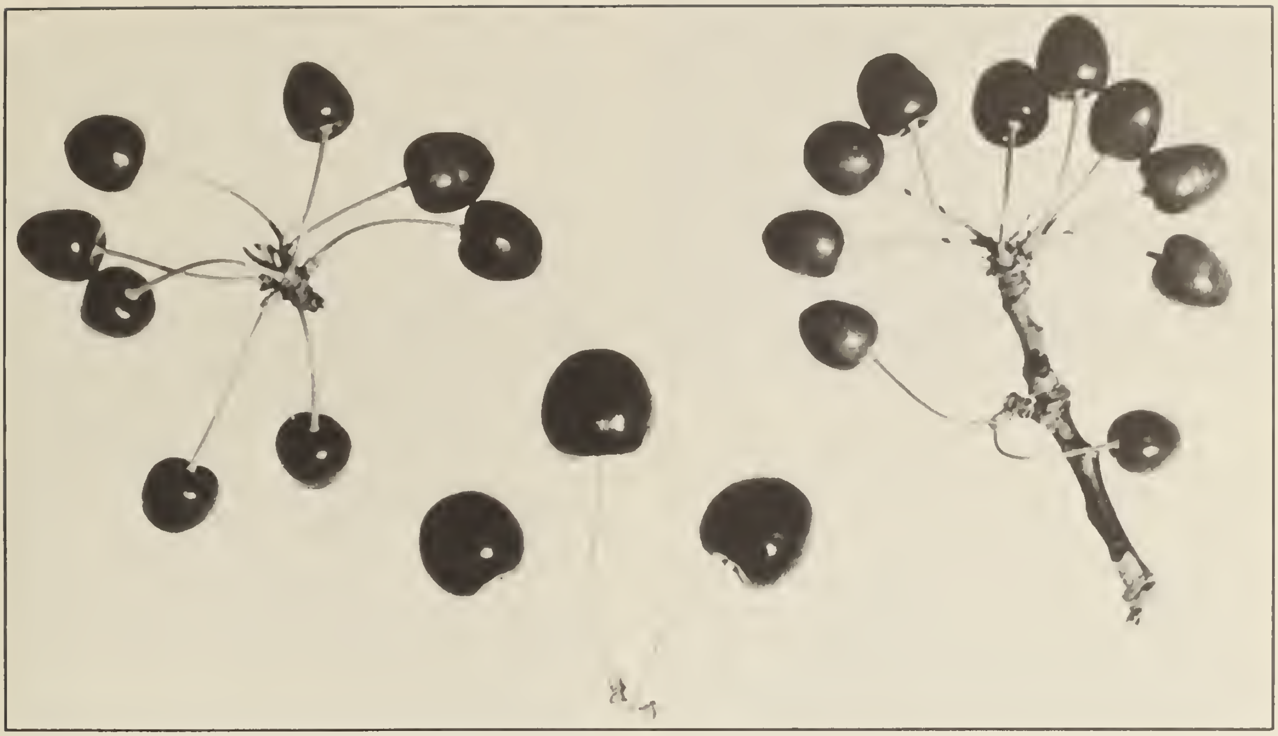

Large healthy fruits (center) and two spurs with small Little Cherry-infected fruits (right and left) from the Kootenay region of British Columbia.

The time span available for this huge task was relatively short, as the disease symptoms—tasteless, pale, triangular small fruits, instead of the usual juicy, round and delicious B.C. Starpack—are obvious only during the 10 days before harvest. The results of this survey were reassuring and confusing at the same time: apparently the disease had been brought under control in the immediate area of the first outbreak, as only one more infected tree was found, but four more Little Cherry trees were detected in scattered locations as far as 30 miles away from the originally affected orchard. Could the disease have spread that far already, or had these trees become infected from a different source?

Further checks revealed that throughout the Okanagan Valley a few ornamental cherries had survived the legal ban on these trees, and had apparently served as reservoirs from which the disease had again spread into commercial orchards. A later survey showed that 20 trees of the highly-infected flowering cherry cultivars 'Kwanzan' and 'Shirofugen' had escaped the watchful eyes of district horticulturists and pathologists. While 20 flowering cherries among 30,000 commercial cherry trees may not sound like very many, they were enough to serve as "starters" for what could have been another devastating Little Cherry epidemic. By now these few infected commercial cherries and all flowering cherries (we hope) have been cut down.

And the risk of further outbreaks? We'd love to say "Zero" but plant pathologists are pessimists by profession, so we'll cautiously say "Greatly reduced!" For the people directly involved, district horticulturists, summer students, growers, and provincial as well as federal pathologists, the control effort meant more than just another hectic emergency: it was proof that a complex field problem which involves several unknowns, no previous budget, tricky legal situations, and a poorly-understood virus as main culprit, can be solved if the groups involved maintain close cooperation and a mutual understanding of their goals and methods. If there should be further outbreaks there will at least be a pattern to follow in attempts to bring them under control.

Out of the work in the Okanagan has come a renewed interest in Little Cherry, and a ray of hope which may make future control efforts superfluous: a new cherry selection, provisionally called 'Kootenay Bay Lambert,' has been planted in several areas near abandoned infected orchards in the Kootenays, and so far has remained free of natural infection.

This "field resistance" is apparently based on an aversion of the virus vector to the new cultivar; as a result of this, the Kootenay Bay Lambert trees escape infection from Little Cherry. If this situation continues, and if Kootenay Bay Lambert lives up to its early promise of being equal to the standard Lambert in yield and quality, then there should be a good chance that another kind of battle will also be won, and that the once-flourishing cherry industry in the Kootenays can be re-established. ■

H. S. PEPIN

Le champignon passe l'hiver dans les bleuets tombés et produit au printemps des ascospores infectieuses. Les pousses infectées et les grappes de fleurs se flétrissent donnant alors des spores conidies qui contaminent de nouveau les fleurs et les fruits en formation, et ensuite hivernent. Comme moyen de lutte, les chercheurs essaient de trouver des procédés pour interrompre le cycle biologique du pathogène.

MUMMYBERRY OF HIGHBUSH BLUEBERRY...

A CONTROL DILEMMA

Mummyberry, caused by the fungus *Monilinia vaccinii-corymbosi,* causes annual losses of between 8 and 10 percent of the highbush blueberry crop in spite of current control measures. In B.C., blueberries constitute only a small part of the agricultural production but they are an important part of the soft fruit industry. They generate about 1 million dollars in direct payments to the farmer and over 10 million dollars in the economy below the retail level.

Control measures now in use are costly and not adequate. At best, they reduce the severity of the disease by about 65 percent. At worst, some of the control measures are environmentally dangerous. Dinitro and dinitroamine herbicides are used to destroy the sporulating apothecia on the ground. Toxicologists are having a second look at compounds in this class because of the danger to the person applying the spray. At the C.D.A. Research Station, Vancouver, B.C., we are looking for new ways to control the disease. For this objective, knowledge of the life cycle of the organism is required.

Monilinia vaccinii-corymbosi overwinters in the mummified blueberries which have fallen to the ground. During the winter the fungus replaces the blueberry tissue and in the spring produces a stalked, cup-shape structure called an apothecium which protrudes from the leaf debris. As the apothecium matures it produces ascospores which are discharged into the air currents as the relative humidity drops below 80 percent during the day. Apothecia develop in a very close relationship with the blueberry bushes so that the spores mature and are discharged just as the buds swell and begin to open. The ascospores are carried to the newly opened undifferentiated tissue of the buds which they infect. About 3 to 4 weeks after infection the developing leaf shoots or flower clusters suddenly wilt and turn dark brown. A day or two later white powdery masses of spores called conidia appear on the wilted shoots or flower clusters. The spores are carried to the opening flowers. Spores deposited on the stigma germinate, grow down the style and infect the ovary where they remain quiescent while the fruit develops. At maturity the infected fruit,

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which up to now has appeared normal, turns salmon-pink instead of the usual dark blue. The salmon-pink external skin of the berry sloughs off leaving a silver gray, miniature pumpkin-like structure which falls to the ground. This is the overwintering stage which completes the cycle.

Considering the millions of spores that are released into the air, the efficiency of infection is very low. Both ascospores and conidia are about equally inefficient but the ascospore infection causes the greatest losses. When a conidium infects an open flower it destroys one berry but when an ascospore infects the bud of a flower cluster it destroys all the 6 to 14 berries in that cluster, depending on the variety.

At present we try to keep the blueberry bush covered with fungicide so that the ascospores and conidia which come in contact with potential infection sites are killed before they can cause infection. Ground sprays of dinitro herbicides are used to destroy apothecia before they sporulate but these are dangerous to the operator and inefficient.

This disease can be controlled in two ways: by breaking the life cycle either by preventing apothecial development or by stopping mummy production. Attempts to prevent the development of apothecia have failed due to lack of registered chemicals that will destroy them. Chemical companies are understandably reluctant to go to the trouble of getting a chemical registered for a relatively small acreage crop where their returns will be mininal, unless the chemical also shows promise for a range of large acreage crops with a big sales potential. Unfortunately for blueberry growers, no such chemical has yet appeared.

Preventing the development of mummyberry has also failed due to the lack of no one chemical that will control both conidial and ascospore infections. Benomyl, a systemic fungicide, shows great promise for the control of the conidial stage but is relatively inefficient for control of the ascospore stage. Cela 524, an experimental fungicide from Switzerland, will control ascospores but not condia. Unfortunately it is a long way from registration and even if it were to be registered for other crops, it may never be registered for use on blueberries, simply because it is not an economical treatment.

A third possible control measure is the development of resistant varieties. There are sources of resistance but they all are in late varieties of which we already have an oversuppy. It is in early and mid-season varieties that resistance is needed. No doubt in time a breeding program might develop the needed varieties. Time would be required, for blueberries are slow-growing, requiring 5 to 7 years to reach maturity for meaningful yield data and many more for evaluation.

This then is the dilemma of mummyberry control; an important part of our economy, but a low acreage crop with a low chemical sales potential.

At Vancouver we are continuing our research on the life cycle of the mummyberry organism. The information we obtain may eventually lead to more efficient control. ■

(Top) Conidial mass on flower cluster infection

(Middle) Mummified berries in fruit cluster.

(Bottom) Developing apothecia in spring.

FINGERPRINTING BARLEY CULTIVARS

GEORGE FEDAK

Trois systèmes isozymes (segments de chromosomes) isolés à partir de semis d'orge ont été étudiés pour déterminer si la carte chromosomienne des isozymes peut être utilisée pour identifier les cultivars d'orge. On a pu constater que certaines combinaisons de cultivars ayant une ascendance et des caractéristiques de grain semblables pouvaient être différenciées par cette technique.

Traditionally barley cultivars have been distinguished by seed and spike characteristics. These characteristics are determined genetically, but they can be modified by environmental conditions. Factors such as blue aleurone, kernel size, and shape may be markedly influenced by environment.

Identification is confused still further by the fact that most 6-row cultivars of commercial importance are genetically related. They originate from Lion and OAC 21 (a derivative of Manchuria) or from progenies of the two. In early barley breeding programs in this country, much emphasis was put on the production of 6-row malting cultivars. Lion, the source of the smooth-awned character, was used as a parent with OAC 21, because of its malting characteristics and general adaptability. Progeny of these crosses were subsequently intercrossed to produce a large number of the currently-grown cultivars. Of 42 Canadian-bred cultivars, 29 have both Lion and Manchuria as parents at some point in their ancestry, while another 18 have one or the other. The only exceptions are Prospect and Warrior. The similarities in ancestry have resulted in groups of cultivars with similarities in both plant and seed characteristics.

Ideally, all characteristics used to differentiate between varieties should be simple and genetically determined. They should not be modified by environmental conditions.

VARIETY EXCLUSION TESTS

The probability of getting a perfect match between two different varieties decreases as the number of traits by which they are compared is increased. However, this probability never reaches zero. For this reason, an unknown sample cannot be positively identified as coming from a specific variety. However, a sample purported to come from variety X may be compared with that variety and if they do not match in all criteria the sample may be positively excluded from being variety X. It is suggested that variety identification tests would be more properly termed variety exclusion tests.

The difficulties encountered in the use of morphological characters has led to the search for chemical characteristics for variety exclusion tests. Electrophoresis has been particularly useful in this respect. Electrophoresis is basically the migration of molecules in solution under the influence of an electric current; and in our study this principle was applied to groups of enzymes extracted from barley seeds. Enzyme molecules migrate through pores in the agar medium at a rate proportional to the charge on the molecule and inversely proportional to molecular size so that similar molecules will migrate at similar rates and accumulate at specific distances from the point of origin. Under suitable conditions and specific treatments the enzymes can be separated into specific bands. The patterns formed by this protein in the gel after staining may be termed the "fingerprint" for the cultivar. The presence of different enzymes or different concentrations of enzymes will alter the "fingerprint".

We examined three enzyme systems in tissues of 55 cultivars currently grown in Canada. Alpha amylase enzymes were extracted from remnants of the endosperm following five days of seed germination. Esterase and acid phosphatase enzymes were extracted by crushing sections of plumule tissue. A total of nine distinct esterase patterns were identified based on the consideration of numbers or positions of bands in four zones on the gel and arbitrarily numbered from 1 to 9. The distribution of cultivars over the total number of patterns was disproportionate, as 18 cultivars were associated with pattern 1 and only 1 with pattern 3, while the others were fairly uniformly distributed over the remaining patterns.

BARLEY FINGERPRINTS

A typical esterase electropherogram is shown in Fig. 1 with eleven different cultivars represented. Variations in expression of bands in A & C zones form the basis of different patterns. Manchuria, Glabron, Brock and Wisconsin 38 all showed bands at A1. 8 & C4.9 which is characteristic of pattern 1. The cultivars Paragon, Wolfe and Bonanza all showed pattern 4. This pattern differs from group 1 by having a faster moving pair of bands in the C zone at C5.4. Lion, Fergus and Warrior all differed from one another and the above patterns. Warrior with pattern 5 had bands at C5.4 and A1.4. Fergus differed by having pattern 6 with C4.9 and A1.0 while Lion with pattern 8 was distinct with bands at C4.9 and A0.2.

Three types of alpha amylase patterns were detected and identified as DC and DC1 each with two

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bands and DC2C a three-banded pattern. This enzyme system by itself was found to be not particularly useful for cultivar exclusion because of its disproportionate distribution among the cultivars. Forty-one cultivars were associated with the DC pattern, six with DC1 and eight with DC2C.

Three different quadruple-banded acid phosphatase patterns were observed in the cultivars studied so that this system in itself is not particularly useful for cultivar exclusion. However, it was useful in subdividing the large concentrations of cultivars assigned to other enzyme patterns.

We examined the possibility of differentiating my means of electrophoresis cultivars that were similar in seed characteristics. Listed in Table 1 are cultivars that are difficult to identify on the basis of seed characteristics and the enzyme patterns that were unique to the few cultivars considered. The total number of isozyme patterns detected in this study are not shown. Husky, Jubilee and Galt are very similar in seed characters and difficult to differentiate on that basis. As shown in Table 1 Husky and Jubilee have the same esterase and alpha amylase pattern but differ by virtue of acid phosphatase 1 and 2 respectively, while Galt is characterized by esterase 5.

Fergus and Herta, also difficult to differentiate visually, share the same alpha amylase zymotype but differ in both esterase and acid phosphatase patterns.

Figure 1. An electrophoregram showing the esterase zymotypes of eleven contemporary cultivars. Esterase patterns indicated in brackets L-R. Lion (8), Manchuria (1), Glabron (1), Bonanza (1), Brock (1), Paragon (4), Fergus (6), Wong (7), Wolfe (4), Wisconsin 38 (1), Warrior (5).

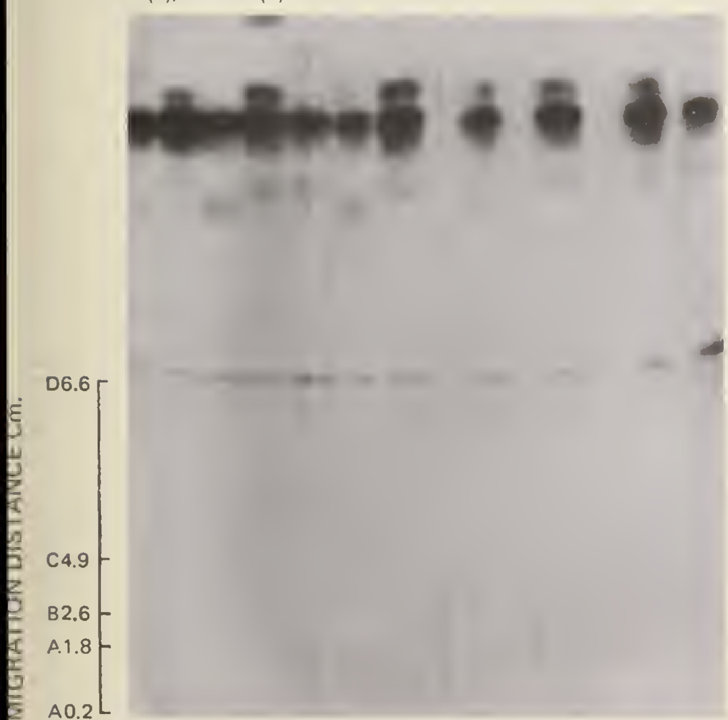


TABLE 1 ISOZYME PATTERNS IN SOME CANADIAN BARLEY CULTIVARS

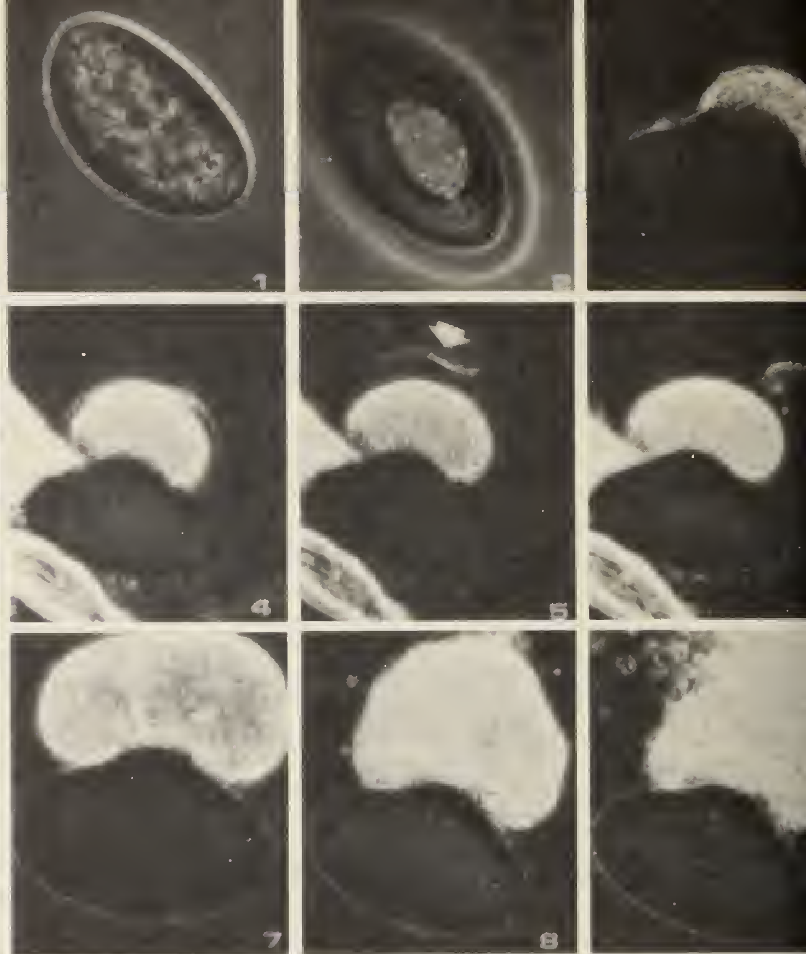
	Acid p'ase 1		Acid p'ase 2		Acid p'ase 3	
Alpha amylase	DC	DC1	DC	DC1	DC	DC1
Esterase 1	Husky		Jubilee			
Esterase 4	Bonanza Herta Conquest Paragon					
Esterase 5	Galt					
Esterase 6					Betzes Fergus Hannchen	

Herta is characterized by esterase 4 and acid p'ase 1, in contrast to Fergus with esterase 6 and acid p'ase 3. Some combinations of cultivars could not be separated using isozyme fingerprints. Betzes and Hannchen appear to be similar in many respects including isozyme patterns. Similarly, Bonanza, Conquest and Paragon, all 6-rowed cultivars with malting potential arising from the same breeding program have inherently similar isozyme patterns as well as seed characteristics. Another aspect of isozyme studies is polymorphism.

In the same way that cultivars such as Herta are composed of certain frequencies of blue and yellow aleurone kernels many cultivars have kernels with different isozyme patterns. Paragon proved to be monomorphic for esterase 4, Bonanza had equal proportions of kernels with esterase 1 and 4 while Conquest was characterized by variations in expression of one particular band in pattern 4. These frequencies were established by examining only 20 kernels per cultivar. If such frequencies hold true in more extensive future studies, polymorphism may be shown to be variety-specific and useful for identification purposes.

The use of isozymes is an efficient and rapid technique permitting the screening of hundreds of individuals per day. It can be non-destructive since only minute sections of tissue are required. Enzyme extraction can be carried out on plumule tissue thus eliminating the need to grow the crop to maturity. Unfortunately relatively few cultivars can be positively identified or excluded in this way. Isozyme markers are genetically determined so cultivars with similarities of parentage and seed characteristics can be expected to be similar enzymatically. The full extent of polymorphism or effects of environment and mutation rate on band expression are not known.

The use of biochemical fingerprinting will probably be restricted to cultivar exclusion at the level of the pedigreed seed trade by an agency such as the Plant Products Division. Such methods will not likely be applicable at the commercial level which requires readily discernable seed characteristics to permit the examination and identification of numerous carloads of grain per day. ■



DISEASED MOSQUITOES

J. A. SHEMANCHUK and H. C. WHISTLER

Les chercheurs continuent à mettre au point un agent de lutte biologique contre les moustiques. Dans le laboratoire, l'effet du champignon pathogène *Coelomomyxes psorophorae* chez une espèce de moustique a donné des résultats très encourageants jusqu'à présent.

Figure 1 (Above left) Thorax and part of the abdomen of a larva of *Culiseta inornata* heavily infected with sporangia of *Coelomomyces psorophorae*.

Figure 2 (Above) Micrographs showing the sequence in the germination of a mature sporangium of *Coelomomyces psorophorae:* 1. Mature sporangium; 2. "Go" stage sporangium looking into open crack; 3. Beginning of release sequence: vesicle swells out of crack in sporangium; 4. Separation of vesicle layers; 5. Outer covering (arrow) separates from vesicle; 6. Outer covering floating free of vesicle; 7. Zoospores swimming inside vesicle; 8. First zoospores breaking free from vesicle; 9. Zoospores swimming out of vesicle.

Figure 3 (Opposite) Longitudinal section of a mature zoospore (X16,000) of *Coelomomyces psorophorae*.

The possible use of a fungus as a biological control agent for mosquitoes dates back to 1921 when one species of the genus *Coelomomyces* was reported to have been found in a larva of the yellow fever mosquito. Since then, this pathogen of mosquito larvae has been reported from every continent and about 30 species have been described. Each species of fungus attacks one particular species of mosquito.

In 1956, one of the fungus species, *Coelomomyces psorophorae,* was found to be parasitic on larvae of the mosquito *Culiseta inornata* in the irrigated areas of southern Alberta. Since this discovery, infected larvae have been found in these areas every year. This indicates that the fungus is well established and widely distributed. Larvae usually are infected during

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July, August, and September. The incidence and rate of infection varies between locations and seasons. In the field, infected larvae of *Culiseta inornata* can be detected because they are darker, larger, and slower in movement than healthy ones.

The body cavity of a heavily infected larva may be a solid mass of small, golden, oval bodies known as sporangia. These sporangia are the resting stages of the fungus, the stage in which the fungus is believed to winter in Alberta. We do not know how mosquito larvae become infected with *Coelomomyces psorophorae.* It is not clear whether the larvae are infected after they ingest the fungus or after the fungus penetrates the integument of the larvae. In any case, the fungus develops principally in the body cavity of the larva.

The impact of *Coelomomyces psorophorae* for reducing the numbers of the mosquito *Culiseta inornata* under natural conditions in southern Alberta is difficult to assess. However, this fungus is an interesting one and we believe it is one of the most promising disease-producing organisms for the biological control of mosquitoes. Its chief feature is that although it will attack and kill the larvae of *Culiseta inornata,* it is harmless to other insects, fish, and animals.

The persistence of this fungus in the irrigated areas of southern Alberta and the ability to colonize the host species of mosquito in the laboratory prompted us to further study this particular host-parasite combination. In 1970, a cooperative project was established between the Department of Botany, University of Washington, Seattle, and the Veterinary-Medical Entomology Section of the CDA Research Station, Lethbridge, to study the germination of resistant sporangia of *Coelomomyces psorophorae.* A procedure for germinating the sporangia has been developed and some of the chemical and physical conditions necessary for germination have been defined. A laboratory procedure for infecting *Culiseta inornata* larvae has been worked out. This has enabled us to maintain limited quantities of *Coelomomyces psorophorae* in the laboratory without having to depend entirely on field collections for a supply of the fungus.

The results of our laboratory experiments to date have been very encouraging. But more research is necessary to define the physical and chemical factors in natural ponds to relate these factors to naturally occurring infections and the survival of the sporangia.

The present state of our knowledge strongly indicates that *Coelomomyces psorophorae* offers a great potential as a biological control agent against populations of *Culiseta inornata* and, possibly, other prairie mosquitoes. ■

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